Financial Frictions in Macroeconomics: Lessons from Advanced and Emerging Market Economies

Dissertation

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The Faculty of Economics, Business Administration and Information Technology of the University of Zurich hereby authorizes the printing of this dissertation, without indicating an opinion of the views expressed in the work.

Zurich, 12.02.2014

Chairman of the Doctoral Board: Prof. Dr. Josef Zweimüller

To my parents

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List of Abbreviations

AIC	Akaike Information Criterion
AR	Autoregression
ARG	Argentina
AUS	Australia
AUT	Austria
BCE	Borrowing Constraint Externality
BIC	Bayesian Information Criterion
BOP	Balance of Payments
BRA	Brazil
BRIC	Brazil, Russia, India, China
CA	Current Account
CAN	Canada
CES	Constant Elasticity of Substitution
CHE	Switzerland
CHL	Chile
CHN	China
CIVETS	Columbia, Indonesia, Vietnam, Egypt, Turkey, South Africa
COL	Colombia
CPI	Consumer Price Index
CRRA	Constant Relative Risk Aversion
CSV	Costly State Verification
CZE	Czech Republic
DJI	Dow Jones Indexes
DSGE	Dynamic Stochastic General Equilibrium
DTI	Debt–to–Income
EGY	Egypt
EIS	Elasticity of Intertemporal Substitution
EMBI	Emerging Market Bond Index
EME	Emerging Market Economy
EMGP	Emerging Market Global Players
FDIC	Federal Deposit Insurance Corporation
FEVD	Forecast Error Variance Decomposition
FOC	First–order Condition
FTSE	Financial Times and Stock Exchange
GDP	Gross Domestic Product
GHH	Greenwood, Hercowitz and Huffman
HH	Household

HP	Hodrick and Prescott
HSOB	Historical Statistics on Banking
HUN	Hungary
IBBEA	Interstate Banking and Branching Efficiency Act
IDN	Indonesia
IFS	International Financial Statistics
IMF	International Monetary Fund
IND	India
KOR	Republic of Korea
LHS	Left–hand Side
LS	Least Squares
M&A	Mergers and Acquisitions
MAR	Morocco
MBHC	Multi–Bank Holding Company
MCMC	Markov Chain Monte Carlo
MEX	Mexico
ML	Maximum Likelihood
MSCI	Morgan Stanley Capital Investment
MUS	Mauritius
MYS	Malaysia
NFA	Net Foreign Assets
PDE	Profit Destruction Externality
PER	Peru
PHL	Philippines
PIH	Permanent Income Hypothesis
POL	Poland
PVMCA	Present Value Model of the Current Account
RBC	Real Business Cycles
RHS	Right–hand Side
ROE	Return on Equity
RRA	Relative Risk Aversion
ROW	Rest of the World
RUS	Russia
RWC	Random Walk Component
SDF	Stochastic Discount Factor
SOE	Small Open Economy
S&P	Standard and Poor's
SWE	Sweden
TFP	Total Factor Productivity
THA	Thailand
TUR	Turkey
TVC	Transversality Condition
VAR	Vector Autoregression
VECM	Vector Error Correction Model
VNM	Vietnam
ZAF	South Africa

Chapter 1

Introduction

The last three decades of the twentieth century witnessed waves of financial deregulation throughout the globe. Widespread financial liberalisation took place at the domestic and international level in both advanced and developing economies. Several countries lifted restrictions on competition in banking through the elimination of interest rate regulations and the permission for foreign banks or non–bank organisations to enter domestic banking markets. Bond and stock markets opened up, too. Nowadays, investors can diversify their portfolios internationally by trading bonds and shares of companies from different parts of the world. Moreover, financial globalisation has been further promoted by the extensive liberalisation of capital accounts, which led to an enormous increase in cross–border asset holdings.

But being more liberal does not mean that today's financial markets are free from imperfections. Financial deregulation can eliminate some sorts of distortions, but leaves other imperfections unaffected. Such frictions, in turn, can have an important impact on the behaviour of economic agents and therefore lead to different macroeconomic outcomes as compared to a frictionless world. Indeed, a large body of academic literature has examined the link between financial frictions and real economic activity. This thesis adds to this field of research and studies the macroeconomic implications of certain frictions in national and international financial markets. In particular, Chapter 2 analyses the effects of financial liberalisation on the US economy, while Chapters 3 and 4 focus on the role of frictions in Emerging Market Economies (EMEs).

Numerous theoretical contributions show that finance matters for the real economy.[1] Bernanke and Gertler (1989) and Carlstrom and Fuerst (1997) were one of the first who tried to incorporate financial frictions in macroeconomic models. In their frameworks, entrepreneurs borrow from households who do not observe the outcome of entrepreneurs' investment projects unless they pay a verification cost. This costly state verification (CSV) implies that investment depends positively on entrepreneurs' net worth. If a negative shock occurs, net worth declines, which leads to less investment. The associated fall in capital and output feeds back in a further drop in entrepreneurial net worth and investment in the subsequent period. As a result, the financial friction increases the *persistence* of the temporary shock. However, the upward shift in capital supply raises the price of capital, which mitigates the additional fall in investment. This effect is different from the propagation of shocks in Bernanke *et al.* (1999). Their model features non–linear capital adjustment costs which actually implies a fall in the price of capital after a negative shock. Hence, financial frictions do not only increase the persistence of shocks but also generate *amplification* effects. Bernanke *et al.* (1999) call this the *financial accelerator*. A similar mechanism is at present in Kiyotaki and Moore (1997). Their model does not feature CSV but introduces a collateral constraint for entrepreneurs. Negative shocks cause a fall in output and asset prices which tightens the borrowing constraint and therefore reinforces the propagation of the initial shock.

Another class of models analyses the impact of idiosyncratic income shocks on the consumption and savings behaviour of individuals. If markets are complete, i.e. a full set of state–contingent Arrow–Debreu securities is available for trade, agents can fully hedge against consumption fluctuations across all possible states of nature. Under incomplete markets, households can engage in perfect consumption smoothing over time and consume the annuity value of discounted lifetime wealth, if there is no uncertainty and the interest rate equals the agent's time preference rate. This outcome is the famous permanent income hypothesis (PIH) originated by Friedman (1957). Yet the PIH does not generally hold in

[1] See Brunnermeier *et al.* (2013) for an excellent overview over financial frictions in macroeconomic models.

a world with uncertainty unless we make the strong assumption of quadratic preferences. Indeed, an influential paper by Aiyagari (1994) shows how under incomplete markets the interplay of uninsurable idiosyncratic income shocks, prudence, and borrowing constraints creates a *precautionary savings* motive. That is, market imperfections create an incentive for self–insurance, which leads to an inefficiently high level of aggregate capital in equilibrium.

More recently, Mendoza *et al.* (2009) have considered a two–economy extension of the Aiyagari (1994) framework to analyse the phenomenon of global external imbalances. They argue that the observed current account imbalances are the result of financial integration across countries that differ in the degree of financial development. Financial contracts can be better enforced in countries with more developed financial markets, such that these countries save less and accumulate more foreign liabilities. Indeed, this provides one possible explanation for why capital flows uphill, i.e. why countries with higher growth rates do not attract foreign capital. Caballero *et al.* (2008) suggest a different solution to this *capital allocation puzzle* (see Gourinchas and Jeanne (2013)). Fast growing emerging markets are unable to generate enough financial assets in order to meet the domestic demand for securities. This excess demand is satisfied by countries with more sophisticated financial markets, such that capital actually flows from poor to rich economies.

Turning to the empirical literature on the macroeconomic implications of financial frictions, several studies suggest that deeper and well–functioning financial markets have beneficial effects on the economy as a whole. A prominent article by King and Levine (1993) employs cross–country regressions and shows that a higher level of financial development leads to higher growth of per capita income. Rajan and Zingales (1998) provide further support for the *growth–finance nexus*. Using industry–level data for a large cross–section of countries, they find that industries that depend more on external finance grow at a lower rate in countries with low financial development. In an important contribution, Jayaratne and Strahan (1996) study the impact of the relaxation of bank branching restrictions in the United States on economic growth. Until the late 1970s, a multitude of state and federal laws prohibited banks from branching freely within and across state borders. During the 1980s, however, more and more states lifted these restrictions on intra– and interstate banking. The result of this gradual deregulation process was an integrated national banking market as we know it today. In fact, Jayaratne and Strahan (1996) show that the intrastate banking reform led to a significant increase in per capita income and output growth.

The paper by Jayaratne and Strahan (1996) was the beginning of a range of empirical studies that examined the impact of US intra– and interstate banking deregulation on the real and financial economy. For instance, Black and Strahan (2002), Cetorelli and Strahan (2006), and Kerr and Nanda (2009) find that the regime change spurred investment in new firm start–ups and led to an increase in the overall number of firms. Cetorelli and Strahan (2006) also show that the average size of non–financial firms declined following the banking reform. What is more, Morgan *et al.* (2004) provide evidence that bank market integration reduced macroeconomic volatility within states. Demyanyk *et al.* (2007) show that interstate income risk sharing improved after banking deregulation. In addition, Hoffmann and Shcherbakova-Stewen (2011) find that intrastate banking liberalisation led to a decline in the pro–cyclicality of consumption risk sharing.

In light of this extensive empirical research, it is surprising that theoretical work on this issue has been very limited. For that reason, **Chapter 2** of my thesis, **"Macroeconomic Implications of US Banking Liberalisation"**, addresses the macroeconomic repercussions of US banking deregulation from a theoretical perspective. I develop a Dynamic Stochastic General Equilibrium (DSGE) model, which features two forms of financial frictions. On the one hand, I follow Kiyotaki and Moore (1997) and assume that the amount entrepreneurs can borrow from banks is subject to a collateral constraint. On the other hand, I build on Gerali *et al.* (2010) and introduce credit frictions by assuming that banks supply loans under monopolistic competition. Banks operate as traditional financial intermediaries. They transfer funds from private households to entrepreneurs in the economy. Prior to deregulation, banks exploit their market power and charge a high mark–up on loan interest rates. Financial liberalisation leads to more vigorous competition among banks, which effectively ameliorates credit market access of entrepreneurs.

To my knowledge, Stebunovs (2008) and Ghironi and Stebunovs (2010) are the only studies that analyse US banking deregulation within a theoretical macro framework. My work is closely related to these two articles. In particular, the way how companies enter and exit the market in my model is borrowed from their papers. Nevertheless, the focus and approach of my analysis is somewhat different from theirs. In my setup, entrepreneurs are investors who fund the creation of firm start–ups. Yet in the models of Ghironi and Stebunovs banks own the firms in the economy after they have financed their establishment. That said, banks act more like venture capitalists rather than financial intermediaries. Moreover, Ghironi and Stebunovs (2010) consider a two–country DSGE model to study the domestic and international repercussions of interstate branching deregulation. They point out that bank market integration might have contributed to the persistent current account deficits in the US. In this vein, their study complements the aforementioned literature on global external imbalances.

The goal of my paper is to contribute to bridging the gap between my theoretical framework and the vast empirical literature on US banking deregulation. To gauge the empirical performance of the model, I apply a state–specific calibration. I simulate the model and construct artificial panel data, which are then used to reproduce various regression exercises implemented in previous studies. As a matter of fact, the model succeeds in both qualitatively and quantitatively replicating several empirical findings. In particular, bank market integration is associated with (i) an increase in investment in new firms, (ii) a decline in average firm size, (iii) an erosion of the bank capital ratio, (iv) a reduction of state business cycle volatility, and (v) improved consumption risk sharing of entrepreneurs.

Chapters 3 and 4 of my thesis investigate the role of frictions for explaining macroeconomic dynamics in emerging markets. Many researchers have documented that EMEs exhibit certain business cycle patterns that are different from those in advanced countries. Four stylised facts about macroeconomic dynamics in EMEs are widely agreed upon: (i) business cycle fluctuations in EMEs are more severe than in developed economies; (ii) there is an excess volatility of consumption relative to income; (iii) net exports and current accounts are strongly countercyclical; and (iv) capital inflows are exposed to so–called "sudden stops".

Understanding these empirical regularities has been at the centre of recent research on macroeconomic fluctuations. Neumeyer and Perri (2005) address these issues in a small open economy (SOE) model with working capital and country risk spreads on the interest rate. They point out that the model matches Argentine business cycles reasonably well if country spreads are induced by domestic fundamentals. In particular, it is able to generate high macroeconomic volatility, countercyclical net exports and a negative correlation between interest rates and GDP. A prominent contribution by Aguiar and Gopinath (2007) analyses a stochastic growth model featuring transitory and permanent productivity shocks. They estimate their model for Mexico and Canada, representing emerging and advanced economies in their analysis. They show that macroeconomic dynamics in Mexico (Canada) are mainly driven by trend (transitory) shocks. This finding provoked Aguiar and Gopinath to state their famous hypothesis that *"the cycle is the trend"* in emerging markets.

Recently, several studies have challenged the results of Aguiar and Gopinath. García-Cicco *et al.* (2010) introduce financial frictions in form of a debt–elastic interest rate in a real business cycle (RBC) framework and estimate the model for Argentina. They find that Argentine business cycles are mainly determined by transitory disturbances, whereas trend shocks play a rather negligible role. Chang and Férnandez (2013) also highlight the importance of financial frictions in understanding macroeconomic dynamics in EMEs. They demonstrate that it is crucial to augment the SOE framework with certain financial market imperfections in order to generate empirically plausible business cycles patterns. The line of reasoning in Boz *et al.* (2011) is a different one. These authors set up a framework in which agents learn to distinguish between trend and transitory shocks. Accordingly, advanced and emerging economies exhibit distinct business cycle phenomena because the latter are characterised by more severe informational frictions.

Chapter 3, entitled **"Business Cycles in Emerging Markets: the Role of Liability Dollarisation and Valuation Effects"**, contributes to this strand of the literature. It is based on joint work with Peter Rosenkranz. The purpose of our paper is to investigate the importance of certain credit market imperfections in different EMEs. To this end, we develop a DSGE model of a small open economy with differentiated home and foreign goods as well as endogenous exchange rate movements. As in Aguiar and Gopinath (2007), total factor productivity (TFP) contains both a transitory and permanent component. We also build on García-Cicco *et al.* (2010) and introduce a debt–elastic interest rate as a reduced form financial market imperfection. Furthermore, our model features the phenomenon of *liability dollarisation*, which can be interpreted as a specific type of financial frictions in EMEs. In this vein, we account for the fact that emerging markets traditionally have had difficulties in borrowing in domestic currency on international capital markets (see Reinhart *et al.* (2003b), Eichengreen and Hausmann (2005), and Lane and Shambaugh (2010)).

The characteristic of liability dollarisation introduces valuation effects in our model. Valuation effects refer to changes in the net foreign asset position that do not arise from the current account but are due to fluctuations in exchange rates and asset prices. The size of these price effects in external balance sheets has been increasing over the last two decades. This observation has attracted great academic attention in recent years. Important contributions in this area of research are Gourinchas and Rey (2007a), Gourinchas and Rey (2007b), Lane and Milesi-Ferretti (2007), and Gourinchas *et al.* (2010). These studies suggest that valuation effects do not only have a non–negligible impact on the dynamics of a country's net foreign asset position but can also play an important role for the propagation of shocks across countries.

We estimate our model using Bayesian techniques for a number of EMEs (Mexico, South Africa, and Turkey) and developed economies (Canada, Sweden, and Switzerland). Therefore, we do not perform a case study but control for potential heterogeneity across countries. Contrary to previous studies in this strand of the literature, we include a (vector–)autoregressive measurement error component to capture off–model dynamics. Regarding business cycles in emerging markets, our main findings are that (i) even though we incorporate financial frictions in the framework, trend shocks are the main determinant of macroeconomic fluctuations, (ii) accounting for liability dollarisation ameliorates the model fit, and (iii) valuation effects on average stabilise changes in the net foreign asset position.

Chapter 4 of my thesis, **"Current Account Dynamics in Emerging Markets: Is the Cycle really the Trend?"**, is the output of a joint project with Mathias Hoffmann. The aim of this chapter is to shed more light on the determinants of macroeconomic dynamics in a large number of EMEs. In particular, we examine the sources behind the strong countercyclicality of the current account in these countries. As already mentioned, Aguiar and Gopinath (2007) explain this phenomenon by arguing that EMEs are particularly prone to permanent shocks. By contrast, García-Cicco *et al.* (2010) and Chang and Férnandez (2013) suggest that it is not permanent shocks but transitory disturbances in combination with financial frictions that determine business cycle patterns in these countries. As a result, the quantitative–theoretical RBC literature on emerging markets provides contradicting evidence with respect to the hypothesis that *"the cycle is the trend"*.

We use a different approach to examine whether the cycle is really the trend. Our analysis builds on the empirical literature on the intertemporal approach of the current account and employs a structural time series model. In particular, we estimate a structural Vector Error Correction Model (VECM) for a large cross–section of EMEs. For this purpose, we follow Hoffmann (2001a, 2013) and Kano (2008) and develop an identification scheme to identify permanent, global transitory, and country–specific transitory shocks. Before we take our method to the empirical data, we apply it to model generated time series and show that it does a strikingly good job in tracking the true underlying shocks.

Our empirical analysis suggests that there is no common explanation for the countercyclicality of the current account in EMEs. In only half of the countries, the countercyclicality of the current account indeed results from permanent shocks, whereas transitory shocks account for this phenomenon in the other half of the countries. Interestingly, our results are consistent with the findings of Aguiar and Gopinath (2007) and García-Cicco *et al.* (2010): permanent shocks drive the negative correlation between the current account and income in Mexico, but transitory disturbances explain the countercyclicality of the current account in Argentina. We show that different degrees of domestic and international frictions across emerging markets might provide an explanation for this observation.

Chapter 2

Macroeconomic Implications of US Banking Liberalisation

2.1 Introduction

Is financial liberalisation a bane or boon for the real economy? Well, it depends. For more than a century, much research has been conducted on the relationship between finance and economic activity. In a pioneer contribution, Schumpeter (1912) highlights the essential role of financial intermediaries in promoting innovations and economic prosperity. Well–performing banking systems mobilise funds and allow an allocation of resources to places where they yield highest returns. In this sense, free banking is beneficial as it enhances efficiency and thereby fosters economic growth. On the other hand, the recent financial crisis of 2008 demonstrated how bad real economic activity can suffer if liberal financial systems tend to malfunction. This painful experience has reignited the still ongoing debate on how we should reform bank regulation in order to address financial stability.

This paper investigates an episode of financial liberalisation in the United States that provides support for Schumpeter's ideology. I develop a Dynamic Stochastic General Equilibrium (DSGE) model with credit market frictions that helps to understand various macroeconomic repercussions of the relaxation of intra– and interstate banking limitations through the 1980s and 1990s.

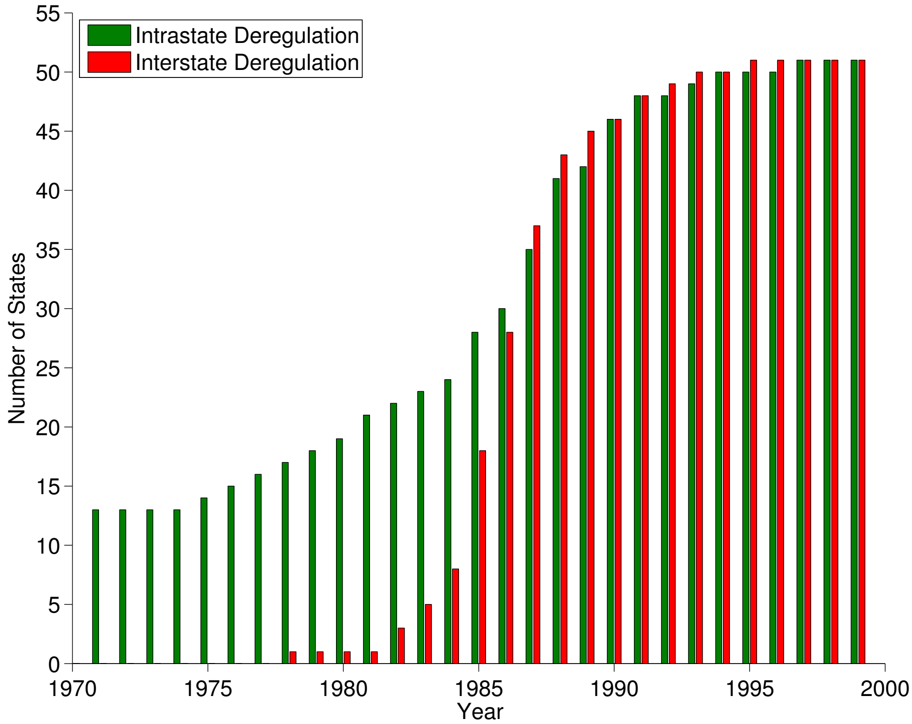
Prior to the 1970s, a multitude of state and federal laws restricted US banks in the geographical coverage of their activities. Most state legislatures designed laws that prevented state banks from opening up branches in different counties within state borders. Some states even barred branching altogether and merely permitted unit banks. Furthermore, the *McFadden Act* of 1927 limited national banks to operate in one state only, and the *Banking Act* of 1933 required national banks to comply with the branching regulations set by the state where they were headquartered. As an attempt to circumvent the legal restrictions on interstate banking, some financial institutions created a Multi–Bank Holding Company (MBHC), which is a corporation that owns several individual banks in different locations. But the Douglas Amendment to the federal *Bank Holding Company Act* of 1956 virtually prohibited MBHCs from acquiring or establishing out–of–state banks.

These barriers to bank entry and expansion effectively curbed competition in local markets and allowed banks to operate in a quasi–monopolistic fashion. Regulatory change only began in the late 1970s, when more and more states began to lift these legal impediments. The gradual removal of geographical restrictions on banking over time is visualised in Figure 2.1, which shows the cumulative number of states that allowed inter– and intrastate banking. As is evident from the diagram, before 1978 only a few states permitted statewide branching, whereas interstate banking was forbidden throughout the country. But the 1980s witnessed a wave of both intra– and interstate banking deregulation across states. A milestone in the deregulation process was the passage of the *Riegle–Neal Interstate Banking and Branching Efficiency Act (IBBEA)* in 1994, which repealed the restrictions on interstate banking and branching. The transition to full intra– and interstate banking in the United States was eventually completed by the late 1990s.[1] This regime change triggered a consolidation in the US banking industry (see Berger *et al.* (1995)), which was associated with improved access to financial services for customers and more vigorous competition among banks (see Stiroh and Strahan (2003)).

Several empirical studies have shown that the annulment of geographical bank entry restrictions had a considerable impact on both the financial and non–financial economy. For instance, an influential paper by Jayaratne and Strahan

[1] See Kane (1996) for a detailed discussion of the IBBEA. Calomiris (2000) and Barth *et al.* (2010) provide comprehensive overviews on the history of the intra– and interstate banking deregulation in the United States.

Figure 2.1: Transition to Full Intra– and Interstate Banking



Notes: Cumulative number of states that permitted intra– and interstate banking and branching, respectively. Deregulation dates of individual states are summarised in Appendix A.

(1996) provides evidence that intrastate branching deregulation accelerated economic growth. Black and Strahan (2002), Cetorelli and Strahan (2006), and Kerr and Nanda (2009) show that the regulatory change also led to an increase in firm creation and a reduction of the average size of non–financial firms (see Cetorelli and Strahan (2006)). Moreover, banking deregulation was associated with a decrease in state business cycle volatility (see Morgan *et al.* (2004)), a tightening of the income distribution (see Beck *et al.* (2010)), an improvement of income risk sharing (see Demyanyk *et al.* (2007)), as well as a decline in the pro–cyclicality of consumption risk sharing (see Hoffmann and Shcherbakova-Stewen (2011)). Regarding the impact on the financial industry, Jayaratne and Strahan (1998) find that bank market integration lowered the interest rate on loans, whereas there was no significant change in bank profitability or deposit interest rates. More recent works demonstrate that bank capital ratios fell (see Hanson *et al.* (2011)) and bank loan commitments increased (see Park (2012)) after the reform.

Despite the vast empirical literature on the real effects of US banking deregulation, this issue has been clearly under–studied from a theoretical viewpoint. To this end, I develop a dynamic general equilibrium framework featuring endogenous firm entry and imperfect competition in banking to shed light on several empirical observations in a coherent framework. Banks play a central role in the model. They act as traditional financial intermediaries, transferring funds from savers to investors in the economy. To be more precise, banks finance the provision of loans to entrepreneurs through sight deposits collected from private households and bank equity accumulated through retained earnings. Entrepreneurs are investors who own profitable capital good producing firms and invest in new firm start–ups.

The model embeds two types of financial frictions. First, as in Kiyotaki and Moore (1997), I assume that entrepreneurs face a borrowing limit. That is, they can only pledge part of their expected future income for collateral purposes. Second, I build on Gerali *et al.* (2010) and let banks operate under monopolistic competition in the credit market. Prior to deregulation, financial intermediaries exploit their market power and charge a high premium on their loan interest rates. This financial market imperfection effectively creates a barrier to external finance for entrepreneurs. Banking deregulation is then simply simulated as a one–time permanent increase in competition among banks. As a result, the decline in the market power of banks directly translates into lower loan interest rates, which improves investors' access to credit.

A major challenge of my analysis is to link my theoretical model to the related empirical literature. Researchers have exploited the fact that states relaxed their geographical restrictions on bank entry at different points in time to study the effects of deregulation through panel regressions. To assess the empirical performance of the model, I reproduce various regression exercises of previous studies based on model generated panel data. For that purpose, I calibrate the model for each individual US state in order to account for potential heterogeneity across states.

Indeed, my model succeeds in both qualitatively and quantitatively replicating several empirical findings. Consistent with Black and Strahan (2002), Cetorelli and Strahan (2006), and Kerr and Nanda (2009), deregulation leads to an increase in firm creation. After the reform, investors can borrow on softer terms, which induces them to finance more firm start–ups. This rise in the number of producers in the economy reduces the relative size of an individual firm. According to Cetorelli and Strahan (2006), this is exactly what happened in the US after the annulment of intra– and interstate branching restrictions.

Furthermore, concurrent with the findings of Morgan *et al.* (2004), bank market integration is associated with a decline in the state–level volatility of output and personal income of private households and entrepreneurs. In fact, featuring different stochastic exogenous shocks on technology, the collateral value pledged by entrepreneurs, and bank competition, the model generally predicts ambiguous effects of deregulation on macroeconomic variability. Deregulation dampens the responses following disturbances to productivity and bank competition, but exaggerates the effects of a shock to the collateral value. Overall, the model suggests a stabilisation of the business cycle after the reform, because the mitigated effects of productivity and competition shocks outweigh the amplified reaction to changes in the collateral value.

Finally, the regime switch improves consumption risk sharing of entrepreneurs, but does not affect insurance of private households. Prior to deregulation, credit is expensive and collateral constraints are tight so that business owners have difficulties in buffering consumption against fluctuations in their portfolio income. Financial liberalisation improves their access to banking services, which allows them to better hedge consumption against income shocks. This result to some extent mirrors the findings of Demyanyk *et al.* (2007) who show that income insurance increased markedly after the transition to interstate banking. They point out that the effect is more pronounced in states where small businesses are more important, which emphasises the crucial role of bank finance especially for small firms. In contrast, Hoffmann and Shcherbakova-Stewen (2011) report that there is no impact at all on average consumption risk sharing.

My work is closely related to Ghironi and Stebunovs (2010) who analyse the domestic and international ramifications of interstate banking deregulation using a two–country DSGE framework. They show how bank market integration may have contributed to the growing external imbalances and persistent real exchange rate appreciation in the US during the 1980s and 1990s. I follow their approach in formalising product market entry and exit in my model. That is, the creation of new firms is subject to sunk setup costs and existing producers face an exogenous business closure shock. A crucial difference between their setup and the one presented in this article is the way how the financial sector is modelled. In Ghironi and Stebunovs (2010), banks can basically be interpreted as venture capitalists who own the stock of firms in the economy. In contrast, my paper explicitly distinguishes between financial intermediaries and entrepreneurs. This separation disentangles market power of banks from competition in the product market and allows to examine the impact of financial liberalisation on different agents, i.e. workers and capitalists. Finally, my work also relates to a burgeoning literature that tries to incorporate fully fledged banking sectors in dynamic macro models. Important contributions in that area have been made by Adrian and Shin (2010), Gerali *et al.* (2010), Meh and Moran (2010), Gertler and Kiyotaki (2010), and Gertler and Karadi (2011).

The remainder of the paper is organised as follows. The next section introduces the theoretical framework. Section 2.3 outlines the state–specific calibration of the model. In Section 2.4, I discuss steady state effects and transition dynamics of banking deregulation. Section 2.5 scrutinises the empirical performance of the model by reproducing various econometric exercises of previous studies. A few concluding remarks appear in Section 2.6.

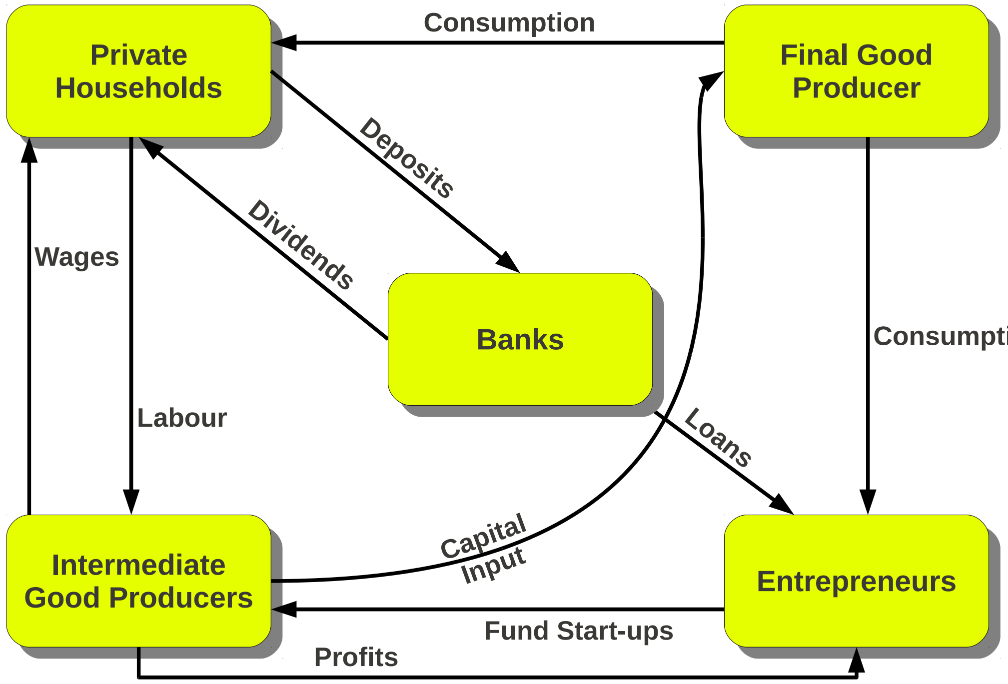
2.2 Model Environment

This section introduces a dynamic general equilibrium model, which will be later used to investigate the macroeconomic repercussions of US banking liberalisation.[2] I use a closed economy setup describing individual US federal states.

Figure 2.2 outlines the structure of the model. The theoretical economy com-

[2] A detailed formal description of the model environment including all derivations is presented in Appendix A.

Figure 2.2: Structure of the Model Economy



prises five types of agents. There is a unit mass of identical, infinitely lived *private households*, who work, consume and save. The producing economy consists of a representative *final good producer* and a continuum of profitable *intermediate good firms*. These intermediate good firms are owned by *entrepreneurs*, who finance the establishment of new firm start–ups. We can think of entrepreneurs as small business owners who – as opposed to big enterprises – cannot obtain funds through national securities markets. Hence, their only source of external funding are loans supplied by a continuum of *banks*.

The financial system is characterised by substantial credit market frictions. Prior to deregulation, competition in the financial industry is curtailed, which enables banks to charge high interest rates on their loans. Expensive credit deters entrepreneurs from borrowing in order to fund investment in new firms. Financial liberalisation results in a more competitive loan market, such that business owners' access to external finance improves.

Although the model abstracts from interstate trade and capital flows, it features both state–specific and country–wide exogenous productivity shocks. Also, there is no money in the model, such that all variables are expressed in real terms, i.e. in units of the homogeneous final good.

2.2.1 Private Households

There is a representative private household with a unit mass of identical, atomistic, infinitely lived members. The expected lifetime utility of the representative household is

$$\mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t^H, 1 - l_t),$$

where E_0 denotes the expectation operator conditional on the information set available at date zero, $\beta \in (0, 1)$ is the subjective discount factor, and c_t^H is the household's consumption at time t. For convenience, total time endowment in each period is normalised to one and the agent devotes a fraction of l_t to work and $1 - l_t$ to leisure activities.

Household's preferences are characterised by a standard Cobb–Douglas Constant Relative Risk Aversion (CRRA) period utility function of the form

$$u(c_t^H, 1 - l_t) = \frac{\left[(c_t^H)^{\xi}(1 - l_t)^{1-\xi}\right]^{1-\gamma}}{1 - \gamma},$$

where $\xi \in (0, 1)$ measures the importance of consumption relative to leisure in determining the agent's instantaneous utility and $\gamma \geq 1$ is a parameter that governs the risk attitude of the private household.

As in Ghironi and Stebunovs (2010), the representative agent has access to two different types of financial securities. On the one hand, it can hold risk–free bank deposits, while on the other hand, it can buy stocks in a risky mutual fund of banks. Each period t, the household enters with d_t deposit holdings and purchases d_{t+1} new deposits. Bank deposits have a maturity of one period. To keep matters simple, I assume that there is no default risk of banks. That is, at time t, the household always receives back the full amount of its deposits d_t plus a risk–free return r_t, where r_t denotes the interest rate between time $t - 1$ and t, known with certainty at date $t - 1$. Furthermore, the agent holds x_t shares in the mutual fund and buys x_{t+1} new shares. The mutual fund consists of a continuum of all banks in the economy. At time t, each individual bank ι pays out part of its profits as dividends $a_t(\iota)$ to the fund's shareholders. Accordingly, total dividend payments amount to $\int_\iota a_t(\iota)d\iota$. Since shareholders are entitled to receive dividend payments in the future, the price of one stock in the fund must be equal to the value of claims to all banks' future dividends. Let $\nu_t(\iota)$ denote the price of such a claim to bank ι. This implies that the price of a share in the fund has to be $\int_\iota \nu_t(\iota)d\iota$. As a result, the overall payoff of a stock is the sum of the share price and dividends, i.e. $\int_\iota(a_t(\iota) + \nu_t(\iota))d\iota$. Finally, the household also earns labour income $w_t l_t$ from supplying l_t units of labour, where w_t denotes the real wage rate.

In sum, the representative household generates income from work, the redemption of deposits plus accrued interest, dividends, and the liquidation of the current stock portfolio. Household expenses are given by the sum of consumption and the purchase of new deposits and shares. The period budget constraint of the representative agent can therefore be written as

$$d_{t+1} + x_{t+1}\int_\iota \nu_t(\iota)d\iota + c_t^H \leq (1+r_t)d_t + x_t\int_\iota (a_t(\iota) + \nu_t(\iota))d\iota + w_t l_t. \tag{2.1}$$

The household takes prices as given and seeks to maximise expected lifetime utility by choosing c_t^H, l_t, d_{t+1}, and x_{t+1}, subject to the period budget constraint (2.1), given d_0 and x_0. The solution to the household's optimisation problem yields:

$$\frac{\left((c_t^H)^\xi(1-l_t)^{1-\xi}\right)^{1-\gamma}}{c_t^H} = \beta(1+r_{t+1})\mathrm{E}_t\left[\frac{\left((c_{t+1}^H)^\xi(1-l_{t+1})^{1-\xi}\right)^{1-\gamma}}{c_{t+1}^H}\right], \tag{2.2}$$

$$\nu_t = \beta\mathrm{E}_t\left[\left(\frac{(c_{t+1}^H)^\xi(1-l_{t+1})^{1-\xi}}{(c_t^H)^\xi(1-l_t)^{1-\xi}}\right)^{1-\gamma}\frac{c_t^H}{c_{t+1}^H}(a_{t+1}+\nu_{t+1})\right], \tag{2.3}$$

$$w_t = \frac{1-\xi}{\xi}\frac{c_t^H}{1-l_t}, \tag{2.4}$$

where $\nu_t \equiv \int_\iota \nu_t(\iota)d\iota$ and $a_t \equiv \int_\iota a_t(\iota)d\iota$.

Equation (2.2) represents the intertemporal Euler equation with respect to bank deposits. Condition (2.3) is a version of the Lucas (1978) consumption–based asset pricing formula. It states that the share price of the mutual fund must be equal to its expected discounted future payoff, where $m_{t,t+1} \equiv \beta\left(\frac{(c_{t+1}^H)^\xi(1-l_{t+1})^{1-\xi}}{(c_t^H)^\xi(1-l_t)^{1-\xi}}\right)^{1-\gamma}\frac{c_t^H}{c_{t+1}^H}$

denotes the pricing kernel or stochastic discount factor (SDF) between period t and $t+1$. Finally, equation (2.4) describes the intratemporal labour–leisure trade–off.

An optimal contingent plan for consumption, work, deposit and share holdings is described by sequences $\{c_t^H\}_{t=0}^{\infty}$, $\{l_t\}_{t=0}^{\infty}$, $\{d_{t+1}\}_{t=0}^{\infty}$, and $\{x_{t+1}\}_{t=0}^{\infty}$, satisfying the first–order conditions (2.2)–(2.4), the budget constraint (2.1), as well as the transversality conditions for deposits and shares given by

$$\lim_{T\to\infty} \mathrm{E}_t \left[\prod_{k=1}^{T-1} \frac{d_{t+T}}{1+r_{t+k}} \right] = 0 \quad \text{and} \quad \lim_{T\to\infty} \mathrm{E}_t \left[m_{t,t+T} v_{t+T} \right] = 0,$$

respectively, where $m_{t,t+T} = \beta^T \left(\frac{(c_{t+T}^H)^{\xi}(1-l_{t+T})^{1-\xi}}{(c_t^H)^{\xi}(1-l_t)^{1-\xi}} \right)^{1-\gamma} \frac{c_t^H}{c_{t+T}^H}$ is the T period SDF.

2.2.2 Firms

Final Good Producers

The final good is manufactured in a perfect competitive industry. A final good producer employs differentiated intermediate or capital good varieties to produce the homogeneous final good. At time $t = 0, 1, 2, \dots$, there is a continuum of capital good inputs of measure n_t available. Technology is described by a standard Dixit and Stiglitz (1977) Constant Elasticity of Substitution (CES) production function of the form

$$y_t = \left(\int_0^{n_t} k_t(\omega)^{\frac{\phi-1}{\phi}} d\omega \right)^{\frac{\phi}{\phi-1}},$$

where y_t is the output amount of the final good, $k_t(\omega)$ denotes the input quantity of capital good component $\omega \in [0, n_t]$, and $\phi > 1$ represents the constant elasticity of substitution between different input varieties.

Perfect competition and constant returns to scale imply that the market size is indeterminate which allows to consider a representative firm. Since the producer has to purchase intermediate goods in each period, the representative firm's objective can be described by solving a series of static, one–period profit maximisation problems. Accordingly, the representative producer chooses differentiated intermediate good inputs to maximise profits:

$$\max_{k_t(\omega)} \quad \left(\int_0^{n_t} k_t(\omega)^{\frac{\phi-1}{\phi}} d\omega\right)^{\frac{\phi}{\phi-1}} - \int_0^{n_t} p_t(\omega)k_t(\omega)d\omega, \qquad \forall\, t = 0, 1, 2, \ldots,$$

where $p_t(\omega)$ is the price for variety ω.

First–order conditions with respect to each specific capital good input ω are given by

$$p_t(\omega) = \left(\frac{y_t}{k_t(\omega)}\right)^{\frac{1}{\phi}}, \qquad \forall\, \omega \in [0, n_t]. \tag{2.5}$$

Equation (2.5) states the common optimality condition under perfect competition. The marginal product of each intermediate good input must be equal to its price.

Intermediate Good Producers

At date t, each capital good producer ω hires $l_t(\omega)$ labour units to produce a differentiated variety. The production function is identical for all firms and takes the simple form of

$$k_t(\omega) = z_t l_t(\omega),$$

where z_t denotes exogenous labour–augmenting technology. I assume that the productivity process z_t contains both a state–specific component $z_{s,t}$ and a country–wide component $z_{c,t}$, such that $z_t = z_{s,t} z_{c,t}$.

Because intermediate goods are imperfect substitutes in the production technology of the final good sector, capital good firms act in a monopolistic competitive fashion. The objective of an individual capital good firm ω is to set the price $p_t(\omega)$ in order to maximise profits subject to the demand for its variety by the representative final good producer determined by equation (2.5):

$$\max_{p_t(\omega)} \quad \pi_t^F(\omega) = p_t(\omega)k_t(\omega) - \frac{w_t}{z_t}k_t(\omega), \qquad \forall\, t = 0, 1, 2, \ldots,$$
$$\text{subject to (2.5).}$$

The first–order condition for this problem is given by

$$p_t(\omega) = p_t = \frac{\phi}{(\phi - 1)} \frac{w_t}{z_t}. \tag{2.6}$$

Condition (2.6) indicates that the price of an intermediate good is simply determined by a constant mark–up of $\frac{\phi}{\phi-1}$ over marginal costs $\frac{w_t}{z_t}$. This premium as well as marginal costs are common to all capital good producers, such that all firms choose the same price–quantity combination, i.e. $p_t(\omega) = p_t$ and $k_t(\omega) = k_t$. As a consequence, the production function in the final good sector simplifies to

$$y_t = n_t^{\frac{\phi}{\phi-1}} k_t, \tag{2.7}$$

and condition (2.5) can be rewritten as

$$p_t = \left(\frac{y_t}{k_t}\right)^{\frac{1}{\phi}}. \tag{2.8}$$

Finally, profit of a capital good firm is given by

$$\pi_t^F = \frac{1}{\phi} \frac{y_t}{n_t}. \tag{2.9}$$

2.2.3 Entrepreneurs

The economy is inhabited by a discrete number $\mu_E > 1$ of risk–averse entrepreneurs or investors. They own the stock of intermediate good producers in the economy and therefore receive all profits generated in that sector. In addition to their firm portfolio income, entrepreneurs can finance consumption of the final good and investment in new firm start–ups through loans provided by banks. In fact, I assume that bank loans are the only source of external finance for investors. In that sense, we can interpret entrepreneurs as small business owners who do not have access to funding through corporate bond or equity markets.

The expected lifetime utility of entrepreneur j is

$$\mathrm{E}_0 \sum_{t=0}^{\infty} \beta_E^t u_E(c_t^E(j)),$$

where $\beta_E \in (0,1)$ is the subjective discount factor and $c_t^E(j)$ denotes entrepreneur j's consumption at date t. Preferences are identical among all investors and given by a standard power utility function

$$u_E(c_t^E(j)) = \frac{(c_t^E(j))^{1-\gamma_E}}{1-\gamma_E},$$

where $\gamma_E \geq 1$ represents the Arrow–Pratt coefficient of relative risk aversion or the inverse of the elasticity of intertemporal substitution.

At each time t, entrepreneur j holds a portfolio of $n_t(j)$ capital good firms and funds the foundation of $n_{e,t}(j)$ new firms. Firm entry and exit is analogue to Ghironi and Melitz (2005), Bilbiie *et al.* (2011), and Ghironi and Stebunovs (2010). The establishment of new enterprises is costly. Before a firm enters the market and starts to produce, the investor has to finance an exogenous sunk setup cost. For the sake of simplicity, this entry cost is assumed to be fix and amounts to one unit of the homogeneous final good.[3]

A firm entrant in period t is only able to start production in period $t+1$. This induces a one period time–to–build lag in the economy. As shown in Section 2.2.2, production in the intermediate good sector does not incur fixed costs. This implies that an operating firm produces in every period until it is forced to shut down and exits the market. In particular, I assume that firm exit occurs exogenously. With independent probability $\delta \in (0,1)$, an incumbent producer will be hit by the close–down shock and vanishes at the end of every period.[4] The fact that only existing producers face the exit shock implies that a firm established during period t will operate at least in period $t+1$ before it is subject to potential closure. As a result, the number of firms in entrepreneur j's portfolio evolves according to

[3] As Ghironi and Melitz (2005) point out, we can think of an individual firm as a production line for a specific variety. In this respect, the theoretical model does not distinguish between product innovations that are introduced by new or existing producers.

[4] The reason why I assume an exogenous exit shock, independent of the state of the economy or firm characteristics, is twofold. First, endogenous business closure would substantially complicate the model. Second, empirical evidence suggests that the product and business destruction rate in the US has been invariant over the business cycle. For instance, Broda and Weinstein (2010) find that product creation is strongly procyclical, whereas the destruction of good varieties does not respond heavily to cyclical movements. In addition, Lee and Mukoyama (2008) show that although entry of manufacturing plants in the US is procyclical, exit rates are not substantially different across booms and recessions.

the following law of motion:

$$n_{t+1}(j) = n_{e,t}(j) + (1 - \delta)n_t(j). \tag{2.10}$$

Hence, the dynamic equation for the overall number of capital good producers in the economy can then be written as

$$n_{t+1} = n_{e,t} + (1 - \delta)n_t, \tag{2.11}$$

where $n_t = \sum_{j=1}^{\mu_E} n_t(j)$ and $n_{e,t} = \sum_{j=1}^{\mu_E} n_{e,t}(j)$.

Changes in the firm portfolio are costly. In particular, variations in the number of enterprises involve a quadratic adjustment cost of $\frac{\chi}{2}\left(\frac{n_{e,t}(j)}{n_t(j)}\right)^2 n_t(j)$, where $\chi > 0$ is a constant weighting parameter. The underlying cost function exhibits an increasing marginal cost of portfolio expansion or, symmetrically, shrinking. This specification captures the idea that a more rapid change in the stock of firms results in a more than proportional rise in adjustment costs. Moreover, due to economies of scale, costs are declining in portfolio size. That is, entrepreneurs who own a large number of companies might have more expertise and are therefore more efficient in running their business.

Entrepreneurs have access to external finance through the credit market. They can agree on one–period loan contracts with banks. At each date t, an investor is able borrow $b_{t+1}(j)$ from banks and must reimburse its past obligations $b_t(j)$ plus interest r_t^b. The interest rate r_t^b determines the price of a loan between period $t-1$ and t and is known at date $t-1$. However, as in Kiyotaki and Moore (1997), entrepreneurs face a borrowing limit. The loan capacity of an investor today depends on both expectations about returns of tomorrow's firm portfolio as well as current portfolio size. In particular, the gross loan repayment in period $t+1$ cannot exceed a certain time–varying fraction of expected future income:

$$(1 + r_{t+1}^b)b_{t+1}(j) \leq \kappa_t n_t(j) \mathrm{E}_t \left[n_{t+1}(j)\pi_{t+1}^F\right]. \tag{2.12}$$

Expression $\kappa_t n_t(j)$ in equation (2.12) defines the debt–to–income (DTI) ratio and determines how much future income an investor can pledge as collateral for its debt obligation.[5] I assume that the borrowing limit is increasing in today's size of the portfolio $n_t(j)$, such that a larger stock of firms improves an investor's access to credit.[6] Besides, the DTI ratio is a function of an exogenous random variable κ_t, affecting the quality of future earnings for collateral purposes. In the deterministic steady state, condition (2.12) is assumed to hold with equality.

I follow Iacoviello (2005) and assume that entrepreneurs are less patient than private households, meaning that $\beta > \beta_E$. This assumption is necessary as it avoids a pure self–financing behaviour of investors and assures that there is financial intermediation in equilibrium. Since entrepreneurs are impatient, they do not accumulate enough resources through postponing consumption and investment into the future but demand loans from banks, while private households hold sight deposits.

The objective of entrepreneur j is to choose $c_t^E(j)$, $b_{t+1}(j)$, $n_{t+1}(j)$, and $n_{e,t}(j)$ in order to maximise expected lifetime utility, subject to the period budget constraint

$$c_t^E(j) + n_{e,t}(j) + (1 + r_t^b)b_t(j) + \frac{\chi}{2}\left(\frac{n_{e,t}(j)}{n_t(j)}\right)^2 n_t(j) \leq n_t(j)\pi_t^F + b_{t+1}(j), \tag{2.13}$$

the evolution of firm number (2.10), and the borrowing constraint (2.12), taking b_0 and n_0 as given.

Two first–order conditions of this optimisation problem are non–standard and deserve special attention. First, let us consider the optimality condition with

[5]There is no default risk in the model, since investors always repay their loans. However, the collateral constraint introduces the importance of an entrepreneur's quality in a reduced form. Imagine, if a borrower does not repay its loans, the DTI ratio determines the fraction of entrepreneurial income banks can still appropriate (see Iacoviello (2005)). Thus, the DTI ratio can be interpreted as a measure of banks' willingness to accept firm profits as loan securities.

[6]Imagine that there is an informal credit rating mechanism at work. Banks know the current number of firms owned by a potential borrower. They consider entrepreneurs with large firm portfolios to be notably safe. For this reason, these investors receive better credit ratings and find it easier to obtain loans from banks.

respect to $n_{t+1}(j)$, which represents the intertemporal investment Euler equation:

$$
\begin{aligned}
q_t(j) = \beta_E \mathrm{E}_t &\left[(c^E_{t+1})^{-\gamma_E} \left(\pi^F_{t+1} + \underbrace{n_{t+1}(j) \frac{\partial \pi^F_{t+1}}{\partial n_{t+1}} \frac{\partial n_{t+1}}{\partial n_{t+1}(j)}}_{\text{Profit Destruction Externality}} + \frac{\chi}{2} \left(\frac{n_{e,t+1}(j)}{n_{t+1}(j)} \right)^2 \right) + (1-\delta) q_{t+1}(j) \right] \\
&\underbrace{+ \mu_t(j) \mathrm{E}_t \left[\kappa_t n_t(j) \left(\pi^F_{t+1} + \underbrace{n_{t+1}(j) \frac{\partial \pi^F_{t+1}}{\partial n_{t+1}} \frac{\partial n_{t+1}}{\partial n_{t+1}(j)}}_{\text{Profit Destruction Externality}} \right) \right] + \beta_E \mathrm{E}_t \Big[\mu_{t+1}(j) \kappa_{t+1} n_{t+2}(j) \pi^F_{t+2} \Big]}_{\text{Borrowing Constraint Externality}},
\end{aligned}
$$

where $\mu_t(j)$ denotes the Lagrange multiplier for the borrowing constraint and $q_t(j)$ is the shadow price of a firm.

This condition states that the value of an additional firm $q_t(j)$ has to be equal to the expected discounted sum of the increase in total profits received from the portfolio, the contribution to lower adjustment costs, and the future shadow price of the firm, plus the value of the improvement of today's and tomorrow's borrowing conditions. The assumption of a discrete number of entrepreneurs implies that the portfolio decision of entrepreneur j affects the total number of enterprises in the economy and thereby individual firm profits. An increase in the number of producers in the intermediate good sector, *ceteris paribus*, reduces the market share of a single firm and consequently diminishes its profits. Ghironi and Stebunovs (2010) call this effect the profit destruction externality (PDE) of portfolio expansion. The investment Euler equation also incorporates the internalisation of a positive borrowing constraint externatlity (BCE). Investors take into account that a higher $n_{t+1}(j)$ lifts the borrowing limit today and in the next period.

The first–order condition with respect to new firm start–ups $n_{e,t}(j)$ forms an entry condition:

$$
q_t(j) = (c^E_t(j))^{-\gamma_E} \left[1 + \chi \frac{n_{e,t}(j)}{n_t(j)} \right].
$$

Optimality requires that the value of an additional firm given by $q_t(j)$ is equal to the present value of the marginal cost of firm creation.[7]

[7]Proceeding as in Ghironi and Stebunovs (2010), the number of entrants $n_{e,t}(j)$ is strictly positive in every period, implying that the entry condition always holds with equality. I keep the mag-

I impose symmetry across entrepreneurs, such that optimality conditions simplify to[8]

$$(c_t^E)^{-\gamma_E} = \beta_E(1 + r_{t+1}^b)\mathrm{E}_t\left[(c_{t+1}^E)^{-\gamma_E}\right] + \mu_t(1 + r_{t+1}^b), \tag{2.14}$$

$$\begin{aligned} q_t = \beta_E \mathrm{E}_t\Bigg[(c_{t+1}^E)^{-\gamma_E}\Bigg(\left(1 - \frac{1}{\mu_E}\right)\pi_{t+1}^F + \frac{\chi}{2}\left(\frac{n_{e,t+1}}{n_{t+1}}\right)^2\Bigg) + (1-\delta)q_{t+1}\Bigg] \\ +\mu_t\kappa_t n_t\left(1 - \frac{1}{\mu_E}\right)\mathrm{E}_t\left[\pi_{t+1}^F\right] + \beta_E\mathrm{E}_t\Big[\mu_{t+1}\kappa_{t+1}n_{t+2}\pi_{t+2}^F\Big], \end{aligned} \tag{2.15}$$

$$q_t = (c_t^E)^{-\gamma_E}\left(1 + \chi\frac{n_{e,t}}{n_t}\right), \tag{2.16}$$

and

$$\mu_t\left(\kappa_t n_t \mathrm{E}_t\left[n_{t+1}\pi_{t+1}^F\right] - (1 + r_{t+1}^b)b_{t+1}\right) = 0. \tag{2.17}$$

Conditions (2.14) and (2.15) are the intertemporal consumption and investment Euler equations, respectively. Equation (2.16) is the firm entry condition and equation (2.17) represents a complementary slackness condition for the borrowing limit.

Entrepreneurs choose contingent optimal plans $\{c_t^E\}_{t=0}^{\infty}$, $\{b_{t+1}\}_{t=0}^{\infty}$, $\{n_{t+1}\}_{t=0}^{\infty}$, and $\{n_{e,t}\}_{t=0}^{\infty}$, which conform to the optimality conditions (2.14)–(2.17), the resource constraint (2.13), and the transversality condition $\lim_{T\to\infty}\mathrm{E}_t\left[\prod_{k=1}^{T-1}\frac{b_{t+T}}{1+r_{t+k}^b}\right] = 0$.

2.2.4 Banks

Financial intermediation in the economy is conducted by a continuum of banks of measure one. Banks have two sources to finance lending to entrepreneurs. On the one hand, they raise funds through collecting deposits from private households. On the other hand, they accumulate bank capital through retained earnings.

The market for deposits is perfectly competitive and banks take the deposit interest rate r_{t+1} as given. In contrast, financial frictions in the loan market allow banks to benefit from market power in performing their lending activities. I follow Gerali *et al.* (2010) and assume that financial intermediaries act under monopolistic competition in the credit market. Banks supply differentiated varieties of loans

nitude of exogenous shocks in the economy small enough in order to ensure positive investment at all points in time.

[8]In a symmetric equilibrium, all entrepreneurs make identical decisions, such that $c_t^E(j) = c_t^E$, $b_t(j) = \frac{1}{\mu_E}b_t$, $n_t(j) = \frac{1}{\mu_E}n_t$, $n_{e,t}(j) = \frac{1}{\mu_E}n_{e,t}$, $q_t(j) = q_t$, and $\mu_t(j) = \mu_t$.

to investors, which are aggregated according to a Dixit and Stiglitz (1977) CES aggregator. Thus, total demand for bank loans is given by

$$b_{t+1} = \left(\int_{\iota} b_{t+1}(\iota)^{\frac{\epsilon_t - 1}{\epsilon_t}} d\iota \right)^{\frac{\epsilon_t}{\epsilon_t - 1}},$$

where $b_{t+1}(\iota)$ denotes a specific loan component supplied by bank $\iota \in [0, 1]$, and $\epsilon_t > 1$ is an exogenous stochastic variable that determines the elasticity of substitution between differentiated loans. The elasticity of substitution is a crucial variable in my analysis as it measures the degree of credit market competition in the economy. In particular, a higher value of ϵ_t indicates that individual bank loans are more easily substitutable, which implies more fierce competition among banks.

Investors behave optimally and demand a mix of differentiated loans in order to minimise their debt obligations. Let $r^b_{t+1}(\iota)$ denote the interest rate on loans supplied by bank ι. Cost minimisation of borrowers implies that bank ι faces a loan demand of

$$b_{t+1}(\iota) = \left(\frac{r^b_{t+1}(\iota)}{r^b_{t+1}} \right)^{-\epsilon_t} b_{t+1}, \tag{2.18}$$

where $r^b_{t+1} = \left[\int_{\iota} r^b_{t+1}(\iota)^{1-\epsilon_t} d\iota \right]^{\frac{1}{1-\epsilon_t}}$ determines the average rate charged by banks in the market.

At each date t, banks have to satisfy their balance sheet identity

$$b_t(\iota) = k^B_t(\iota) + d_t(\iota). \tag{2.19}$$

This accounting identity requires that outstanding bank loans (assets) $b_t(\iota)$ are funded by the sum of bank capital (equity) $k^B_t(\iota)$ and sight deposits (liabilities) $d_t(\iota)$.

Banks cannot raise capital by issuing new shares in the mutual fund. However, they are able to set their dividend policy in order to increase equity. During period t, bank ι obtains fresh capital through retained earnings $\pi^B_t(\iota) - a_t(\iota)$, where $\pi^B_t(\iota)$ denotes bank profits. In addition, it takes into account that the administration or management of equity involves costs equal to a constant fraction $\delta^B \in (0, 1)$ of capital. Consequently, the law of motion of bank equity is

$$k_{t+1}^{B}(\iota) = (1 - \delta^{B})k_{t}^{B}(\iota) + \pi_{t}^{B}(\iota) - a_{t}(\iota). \tag{2.20}$$

Financial intermediation is subject to non–interest transaction costs. For instance, we can think of expenses inherent with the acquisition of information about potential creditors or service fees associated with deposit–taking activities. Operating costs are governed by a function $\Theta_t(\iota)$, which is increasing and concave in both newly issued loans $b_{t+1}(\iota)$ and deposits that are due in the next period $d_{t+1}(\iota)$.[9]

Several contributions to the empirical banking literature suggest that there are non–negligible scale economies in the banking industry.[10] Large financial institutions are able to provide their services in a more efficient way and at lower expenses than their smaller rivals. In general, we can imagine that big banking organisations might benefit from improved diversification of risks (see Hughes *et al.* (2001)), an elaborated branch network (see Berger *et al.* (1993)), or, at these days, an ultimate bailout insurance because of "too–big–to–fail". Thus, I assume that transaction costs $\Theta_t(\iota)$ are a decreasing function of current bank size, determined by total assets $b_t(\iota)$.

In light of these considerations, I specify intermediation costs as

$$\Theta_t(\iota) = \theta_0 \left(\frac{1}{b_t(\iota)} \frac{b_{t+1}(\iota)}{k_{t+1}^{B}(\iota)} \right)^{\theta_1}, \tag{2.21}$$

where $\theta_0 > 0$ defines the weight assigned to operating expenses, and $\theta_1 \in (0, 1)$ is a parameter governing the curvature of the cost function.

Financial intermediaries are owned by the stockholders of the mutual fund, i.e. private households. Therefore, the objective of a typical bank is to maximise shareholder value. In particular, at each date t, bank ι sets the interest rate on its

[9]This assumption implies that the more funds a bank transfers from savers to investors in the economy the more costs it has to bear. However, the marginal increase in intermediation expenses is declining. This specification is in contrast to, for instance, the model of Van den Heuvel (2008) in which a bank's transaction costs in are increasing but convex in loans and deposits.

[10]In fact, evidence on scale and scope economies in financial institutions is fairly mixed. For a review on efficiency in financial firms see for instance Berger and Humphrey (1997) or, more recently, Fethi and Pasiouras (2010).

loans $r^b_{t+1}(\iota)$ and chooses bank capital $k^B_{t+1}(\iota)$ in order to maximise the present value of expected future dividend payments. More concisely, the optimisation problem can be stated as

$$
\begin{aligned}
&\max_{r^b_{t+1}(\iota),\, k^B_{t+1}(\iota)} \quad \mathrm{E}_0 \sum_{t=0}^{\infty} m_{0,t} a_t(\iota), \\
&\text{subject to} \quad \pi^B_t(\iota) = \left(1 + r^b_t(\iota)\right) b_t(\iota) + d_{t+1}(\iota) - (1 + r_t)\, d_t(\iota) - b_{t+1}(\iota) - \Theta_t(\iota), \\
&\qquad\qquad (2.18),\ (2.19),\ (2.20),\ \text{and } (2.21),
\end{aligned}
$$

where $m_{0,t} = \beta^t \left(\frac{(c^H_t)^{\xi}(1-l_t)^{1-\xi}}{(c^H_0)^{\xi}(1-l_0)^{1-\xi}} \right)^{1-\gamma} \frac{c^H_0}{c^H_t}$ is the SDF between period 0 and t of risky dividend payments.

Again, I focus on a symmetric equilibrium.[11] The optimality condition for the loan interest rate can be derived as

$$
r^b_{t+1} = \frac{\epsilon_t}{\epsilon_t - 1} \mathrm{E}_t \underbrace{\left[r_{t+1} + \frac{\theta_0 \theta_1}{b_{t+1}} \left(\underbrace{\left(\frac{b_{t+1}}{b_t k^B_{t+1}} \right)^{\theta_1} (1 + r_{t+1})}_{\text{Intermediation Costs}} - \underbrace{\left(\frac{b_{t+2}}{b_{t+1} k^B_{t+2}} \right)^{\theta_1}}_{\text{Scale Economies}} \right) \right]}_{\text{Marginal Cost of Lending}}. \tag{2.22}
$$

Imperfect competition in the credit market facilitates banks to charge a mark–up of $\frac{\epsilon_t}{\epsilon_t - 1}$ over marginal cost of lending. Banks take into account that an expansion of loan supply has two opposite effects on their operating expenses. On the one hand, additional loan supply directly lifts intermediation costs today. This effect is represented by the first term in parentheses on the right–hand side of equation (2.22). On the other hand, an increase in assets, *ceteris paribus*, dampens transaction costs in the next period, because of scale economies. This effect is captured by the second expression in parentheses on the right–hand side of equation (2.22).

The first–order condition with respect to bank capital is

$$
2 = \underbrace{\frac{\theta_0 \theta_1}{k^B_{t+1}} \left(\frac{b_{t+1}}{b_t k^B_{t+1}} \right)^{\theta_1} + \frac{2 + r_{t+1} - \delta^B}{1 + r_{t+1}}}_{\text{Marginal Benefit of Bank Capital}}. \tag{2.23}
$$

[11] Symmetry among banks and normalisation of the measure of banks to one imply that $r^b_{t+1}(\iota) = r^b_{t+1}$, $b_{t+1}(\iota) = b_{t+1}$, $d_{t+1}(\iota) = d_{t+1}$, $k^B_{t+1}(\iota) = k^B_{t+1}$, and $\pi^B_{t+1}(\iota) = \pi^B_{t+1}$.

Financial intermediaries increase their capital position until the value of additional equity is offset by its marginal cost. Funding loans through capital is costly as it reduces today's cash flow to shareholders. However, banks also internalise that an expansion of the capital base allows to cut sight deposits and thereby operating expenses (first expression on the right–hand side of equation (2.23)). Furthermore, an increase in bank equity leads to higher capital in the next period and consequently raises future dividend payments (second term on the right–hand side of equation (2.23)).[12]

Due to the fact that banks are identical, equations (2.19) and (2.20) as well as bank profits become

$$b_t = k_t^B + d_t, \tag{2.24}$$

$$k_{t+1}^B = (1 - \delta^B)k_t^B + \pi_t^B - a_t, \tag{2.25}$$

and

$$\pi_t^B = \left(1 + r_t^b\right) b_t + d_{t+1} - (1 + r_t)\, d_t - b_{t+1} - \Theta_t, \tag{2.26}$$

respectively.

2.2.5 Exogenous Processes

The model features four exogenous stochastic variables: state–specific total factor productivity $z_{s,t}$, country–wide total factor productivity $z_{c,t}$, collateral quality κ_t, and the elasticity of substitution in the loan market ϵ_t. All stochastic variables follow a univariate first–order autoregressive process in logarithms:

$$\log(z_{s,t+1}) = (1 - \rho_{z_s}) \log(z_s) + \rho_{z_s} \log(z_{s,t}) + u_{z_s,t+1}, \quad \text{with } |\rho_{z_s}| < 1, \tag{2.27}$$

$$\log(z_{c,t+1}) = (1 - \rho_{z_c}) \log(z_c) + \rho_{z_c} \log(z_{c,t}) + u_{z_c,t+1}, \quad \text{with } |\rho_{z_c}| < 1, \tag{2.28}$$

$$\log(\kappa_{t+1}) = (1 - \rho_\kappa) \log(\kappa) + \rho_\kappa \log(\kappa_t) + u_{\kappa,t+1}, \quad \text{with } |\rho_\kappa| < 1, \tag{2.29}$$

$$\log(\epsilon_{t+1}) = (1 - \rho_\epsilon) \log(\epsilon) + \rho_\epsilon \log(\epsilon_t) + u_{\epsilon,t+1}, \quad \text{with } |\rho_\epsilon| < 1, \tag{2.30}$$

[12] Condition (2.23) illustrates that the introduction of intermediation costs is also convenient from an analytical point of view. The properties of the underlying cost function $\Theta_t(\iota)$ ensure that banks are willing to keep a positive amount of bank capital at every point in time. Intuitively, higher bank capital means lower dividend payments. Hence, banks would never have an incentive to finance loans through equity, if financial intermediation was free of charge.

where z_s, z_c, κ, and ϵ denote mean values of the respective process. Error terms $u_{z_s,t+1}$, $u_{z_c,t+1}$, $u_{\kappa,t+1}$, and $u_{\epsilon,t+1}$ are independently and identically distributed draws from a normal distribution with mean zero and standard deviation σ_{z_s}, σ_{z_c}, σ_{κ}, σ_{ϵ}, respectively.

2.2.6 General Equilibrium

To close the model, all markets have to be cleared at every date t. Equilibrium in the market of shares in the mutual fund implies that $x_t = x_{t+1} = 1$. As a result, the budget constraint of the representative private household (2.1) simplifies to

$$c_t^H + d_{t+1} = (1 + r_t)d_t + a_t + w_t l_t. \tag{2.31}$$

The budget constraints of entrepreneurs can be aggregated to

$$\mu_E c_t^E + n_{e,t} + (1 + r_t^b)b_t + \frac{\chi}{2}\left(\frac{n_{e,t}}{n_t}\right)^2 n_t = n_t \pi_t^F + b_{t+1}. \tag{2.32}$$

Consequently, the aggregate resource constraint in the economy can be derived as

$$c_t^H + \mu_E c_t^E + n_{e,t} + \frac{\chi}{2}\left(\frac{n_{e,t}}{n_t}\right)^2 n_t + \Theta_t + k_{t+1}^B - (1 - \delta^B)k_t^B = w_t l_t + n_t \pi_t^F. \tag{2.33}$$

The interpretation of the aggregate resource constraint is standard. Consumption plus investment in both new firms and bank capital (left–hand side of equation (2.33)) must be funded by wage income and dividend income from the firm portfolio (right–hand side of equation (2.33)). Finally, final good market clearing requires that

$$y_t = w_t l_t + n_t \pi_t^F. \tag{2.34}$$

According to Walras' Law, once all markets for goods and assets are in equilibrium, the labour market will be cleared implicitly:

$$l_t = \frac{1}{z_t} n_t k_t. \tag{2.35}$$

2.2.7 Model Solution

The structural model forms a system of 24 non–linear expectational difference equations in 24 variables. This system is characterised by conditions (2.2), (2.3), (2.4), (2.6), (2.7), (2.8), (2.9), (2.11), (2.14), (2.15), (2.16), (2.17), (2.22), (2.23), (2.24), (2.25), (2.26), (2.27), (2.28), (2.29), (2.30), (2.32), (2.33), and (2.34). The model includes four exogenous state variables ($z_{s,t}$, $z_{c,t}$ ϵ_t, and κ_t), and five endogenous state variables (r_t, b_t, n_t, k_t^B, and r_t^b). The remaining 15 variables (c_t^H, c_t^E, w_t, π_t^F, π_t^B, ν_t, y_t, q_t, k_t, p_t, l_t, $n_{e,t}$, μ_t, d_t, and a_t) are controls.

Since there is no closed form solution to this problem available, the solution has to be approximated. To this end, I log–linearise the system around its deterministic steady state and solve the resulting log–linear approximation using the modified Blanchard and Kahn (1980) methodology suggested by Klein (2000).

2.3 Calibration

To make the framework amenable for empirical analysis, I calibrate the model for each US state and the District of Columbia. In particular, I choose a state–specific calibration of β, μ_E, δ^B, θ_0, and ϵ, while the remaining parameters are pinned down at conventional values. Calibrated values are summarised in Table 2.1. Regarding the state–specific parameters, I report the average value across all states. Parametrisation for each individual state can be found in Appendix A.

Let us first look at the parameter values which are common to all states. I count the time unit t as years and set the subjective discount factor of investors β_E equal to 0.90. This value lies between the implied annual values selected by Carlstrom and Fuerst (1997) and Iacoviello (2005). Furthermore, I fix the curvature parameters in the utility functions of private households and entrepreneurs, γ and γ_E, to one.

Without loss of generality, the mean values of labour productivity z_s and z_c are normalised to one. In addition, consistent with evidence from empirical micro studies (see, for instance, Juster and Stafford (1991)), I pin down l at 0.3, implying that private households spend roughly two thirds of their time endowment for leisure. The elasticity of substitution in the intermediate good sector ϕ is set equal to 5. This calibration yields a 25 percent price mark–up over marginal cost.[13] According to an empirical study by Bernard *et al.* (2010), the annual product destruction in the US amounts to 8.8 percent. Therefore, I choose an exogenous business closure rate δ of 0.088. In addition, I put a fairly small weight on investment adjustment costs and set $\chi = 0.028$ as in Schmitt-Grohé and Uribe (2003).

The model constrains the choice of ξ, the consumption weight in the utility of private households. This parameter does not only play a role for the model dynamics but also features important scale effects with respect to the long–run equilibrium. Therefore, I choose $\xi = 0.3022$ to approximate an entrepreneurial debt to income ratio of 53 percent in the average state, which is close to the corporate leverage ratio in the data observed by Bernanke *et al.* (1999). Furthermore, I calibrate the mean value of the collateral shock variable κ at 10 to obtain a reasonable capital to output ratio of about 2.5 in the average state. The parameter determining the curvature of the financial intermediation cost function θ_1 is harder to specify since there are no comparable values from previous studies. Thus, I set θ_1 equal to 0.5.[14]

Obviously, parametrisation of the exogenous processes is not self–evident. The calibration of the persistence of shocks is based on estimation results in Gerali *et al.* (2010). They have estimated a DSGE model with similar exogenous processes using quarterly data for the Euro area. I pin down the autoregressive coefficients in order to obtain half lives of shocks consistent with those implied by the median of their estimated posterior distributions. Accordingly, I set $\rho_{z_s} = 0.7774$, $\rho_{z_c} = 0.7774$, $\rho_{\epsilon} = 0.4838$, and $\rho_{\kappa} = 0.6388$. Furthermore, I follow King and Rebelo (1999) and select a standard deviation of the productivity innovations of 0.0072. Regarding the volatility of disturbances to bank competition and the collateral value, I assign values to ensure that both real and financial shocks play a non–negligible role in driving the dynamics in the model. In particular, I choose σ_{ϵ} equal to 0.5 and σ_{κ} equal to 0.05. This calibration implies that TFP shocks

[13] There is no customary value for ϕ in the macro literature. Ghironi and Melitz (2005) argue that a mark–up as high as 35 percent is reasonable in models without any fixed cost, whereas Rotemberg and Woodford (1992) suggest a premium of only 20 percent.

[14] Admittedly, the selection of this parameter value is somewhat ad hoc. Nonetheless, robustness checks have shown that the model's performance is rather insensitive to the choice of θ_1.

Table 2.1: Calibrated Values

		General Parameters			
β_E	discount factor entrepreneurs	0.90	κ	mean of collateral shock	10
γ	curvature of household utility	1	$\rho_{z,s}$	state prod. shock persistence	0.7774
γ_E	risk aversion of entrepreneurs	1	$\rho_{z,c}$	country prod. shock persistence	0.7774
ξ	consumption weight in utility	0.3022	ρ_ϵ	competition shock persistence	0.4838
δ	business closure rate	0.088	ρ_κ	collateral shock persistence	0.6388
ϕ	subst. elasticity capital goods	5	$\sigma_{z,s}$	std. dev. state prod. shocks	0.0072
χ	adjustment costs	0.028	$\sigma_{z,c}$	std. dev. country prod. shocks	0.0072
θ_1	curvature intermediation costs	0.5	σ_ϵ	std. dev. of bank comp. shocks	0.5
z_s	mean state labour prod.	1	σ_κ	std. dev. of collateral shocks	0.05
z_c	mean country labour prod.	1			
		State–Specific Parameters			
β	discount factor households	0.9684	θ_0	weight for intermediation costs	1.0131e-05
		(0.0095)			(0.4433e-05)
μ_E	number of entrepreneurs	1.7273	ϵ	mean elasticity of loan demand	1.6062
		(0.1478)			(0.1962)
δ_B	depreciation bank capital	0.0701			
		(0.0176)			

Notes: State–specific parameter values correspond to the average across all states. Standard deviations are reported in parentheses. See Appendix A for calibrated values of each individual state.

account for more than 50 percent of the variation of output and consumption in the pre–deregulation era in the average state, whereas investment in new firms and demand for bank loans are mainly driven by collateral shocks and disturbances in bank competition.

The remaining parameters are chosen state–specifically. My calibration is based on aggregated commercial banking data of the Historical Statistics on Banking (HSOB) available from the Federal Deposit Insurance Corporation (FDIC). In particular, I use state–level data from 1966 up to the year in which a state has lifted its *intrastate* limitations on bank entry.[15] The subjective discount factor β is set to match the annual return on deposits calculated by the total interest payments on deposits divided by total deposits. The cross–state average return on deposits is equal to 3.26 percent implying a value for β of 0.9684. Moreover, I fix the *pre–deregulation* elasticity ϵ, the weight of intermediation cost θ_0, and the depreciation rate of bank capital δ^B to hit four steady state targets: (i) the bank capital to asset

[15] I use the year in which statewide branching via mergers and acquisitions was allowed to determine the deregulation date. These dates are taken from Demyanyk *et al.* (2007) and can be found in Appendix A. Note that some states permitted in–state branching already before the 1970s. For these states I fix the year of deregulation at 1970.

ratio $\frac{k^B}{b}$, (ii) the loan interest rate r^b, (iii) the bank return on equity $\frac{\pi^B}{k^B}$, as well as (iv) the dividend payout ratio $\frac{a}{\pi^B}$. The mean capital ratio across federal states is 7.22 percent. I use the return on net loans and leases to obtain a proxy for the loan interest rate, which is equal to 8.70 percent on average. The return on equity (ROE) is calculated as net income divided by total equity capital. This yields a cross–state mean ROE of 11.74 percent. Finally, I use total declared cash dividends divided by net income to determine the fraction of disbursed bank profits, which is equal to 40.30 percent on average. Based on this parametrisation, the number of entrepreneurs μ_E can then be derived from the steady state conditions of the investment Euler equation (2.15) and the firm entry condition (2.16).

2.4 Banking Deregulation

I now turn to the banking deregulation exercise. Prior to deregulation, geographical barriers on bank entry and expansion allowed banks to benefit from quasi–monopoly power in their local markets. The removal of these restrictions triggered a consolidation in the US banking industry (see Berger *et al.* (1995)). Although the overall number of institutions declined, the number of branches and offices increased remarkably. As a consequence, these regulatory changes brought about greater availability of financial services and enhanced competition among banks (see Stiroh and Strahan (2003)).

In the following, I simulate this regime switch as a one–time permanent increase in the elasticity of substitution between differentiated loans ϵ, implying a permanent reduction of the market power of banks.[16] I pin down the size of the liberalisation shock in order to match a long–run erosion of the bank capital ratio by 0.8 percentage points. This choice is largely consistent with recent empirical evidence found by Hanson *et al.* (2011).

[16]The model describes individual federal states as closed economies. Therefore, I actually do not distinguish between intra– and interstate deregulation in the model. Deregulation leads to more vigorous competition in the banking sector, which is simply captured by a permanent increase in ϵ.

2.4.1 Steady State Effects

Let us first discuss the long–run implications of banking liberalisation. In this subsection, I focus on the model calibrated at the average of state–specific parameter values, which I refer to as the average state model. Table 2.2 summarises the steady state effects of selected variables in the average state.

An increase in the elasticity of substitution ϵ reduces the mark–up on the loan interest rate, such that r^b falls. Lower borrowing costs permanently alleviate business owners' access to external finance. They have an incentive to demand more credit from banks in order to fund a greater number of firm start–ups n_e. This additional investment in entrants is accompanied with an increase in the total number of firms n in the economy. As there are more competitors in the intermediate good sector, market share and thereby profits π^F of each producer shrink. In principle, larger portfolio size and lower firm profits have opposite repercussions on total dividend income of entrepreneurs. Nevertheless, portfolio expansion outweighs the decline in firm profits, such that overall earnings of investors go up, which induces them to raise consumption c^E.

Banks have to fund their increased loan position b. The long–run equilibrium levels of bank equity k^B and deposit interest rate r do not alter since they are determined by constant parameters.[17] As a result, the expansion of the bank balance sheet is reflected by a one–to–one increase in sight deposits d. Likewise, augmented competition in the credit market makes bank lending less profitable, because banks are no longer able to charge a high premium on lending rates. Therefore, banks' only source of revenue dries up to a large extent, such that profits π^B plunge.

The explanation for the steady state changes of the remaining variables is fairly obvious. The representative final good producer employs less of each capital good k, because there is a larger measure of differentiated inputs available. Lower demand for each variety lifts their corresponding marginal product, such that prices go up. Since the price of capital goods is determined through a constant

[17]Steady state bank capital and deposit interest rate can be derived as $k^B = \left(\frac{\theta_0\theta_1}{1-\beta(1-\delta^B)}\right)^{\frac{1}{1+\theta_1}}$ and $r = \frac{1}{\beta} - 1$, respectively.

Table 2.2: Long–Run Effects of Banking Deregulation

ϵ	elasticity of loan demand	31.30	q	shadow price of investment	–2.11
r^b	loan interest rate	–28.28	c^E	entrepreneurial consumption	2.15
r	deposit interest rate	0.00	π^F	firm profits	–5.22
b	loans	12.46	k	intermediate good input	–6.96
d	deposits	13.43	p	intermediate good price	1.87
k^B	bank capital	0.00	w	wages	1.87
π^B	bank profits	–49.28	l	labour supply	0.19
n_e	firm entrants	7.69	c^H	household consumption	1.75
n	firm number	7.69	y	output	2.07

Notes: Percentage changes of steady state levels in the model calibrated at the average of state–specific parameter values.

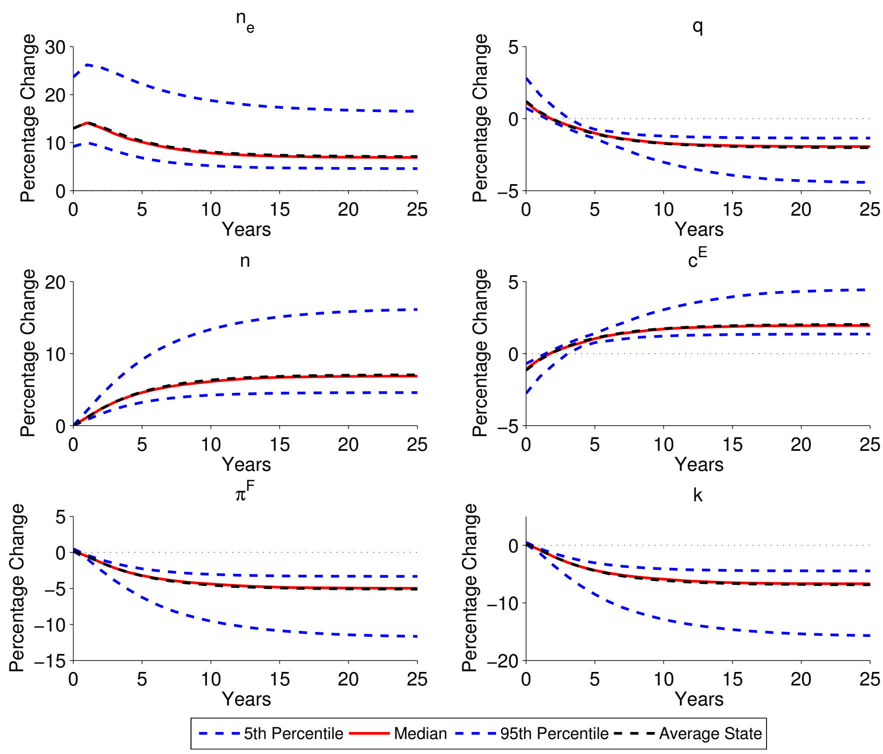
mark–up over marginal cost, the relative increase in prices p and wages w must be equal. That said, the rise in wages induces private households to work more, such that labour supply l goes up. In sum, the increase in labour income and interest payments on savings predominates the drop in dividend payments, such that private households raise their consumption c^H. Finally, market clearing requires that the increase in consumption and investment is met by higher output y.

2.4.2 Dynamic Analysis

Figures 2.3 and 2.4 present selected impulse responses to the deregulation shock. I have computed impulse responses using the model calibrated for each individual state and the average state. The graphs plot the 5$^{\text{th}}$, 50$^{\text{th}}$ and 95$^{\text{th}}$ percentiles of the impulse responses across all states as well as the responses of the average state. The vertical axis shows the percentage deviations from the initial steady state. The horizontal axis indicates the number of years after the shock.

Transition dynamics of investment in new enterprises exhibit a hump–shaped pattern. Entrepreneurs realise that cheaper credit allows them to expand their firm portfolio, which will eventually lead to permanently higher income. Accordingly, the portfolio expansion effect outweighs the profit destruction externality in the short–run. This induces a rise in the shadow value of an additional firm and investors have an incentive to fund new entrants. Since firm creation today is more attractive relative to the post–deregulation equilibrium, investment overshoots for several years after the shock.

Figure 2.3: Selected Impulse Responses to Banking Deregulation I

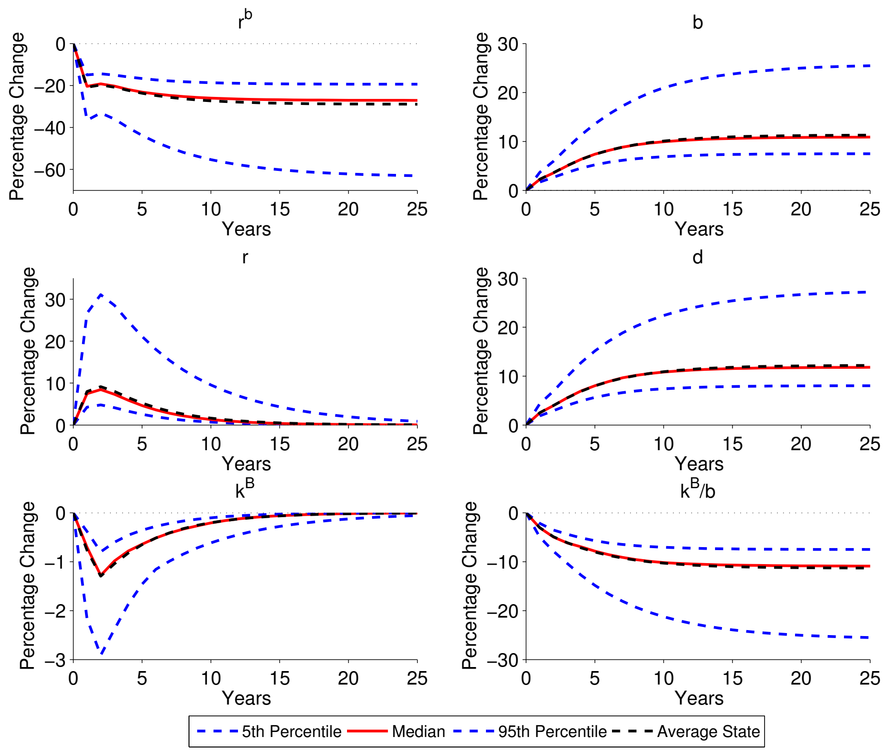


The rise in firm start–ups leads to an increase in the number of enterprises over time. Similar to the model in Ghironi and Melitz (2005), the number of firms plays a central role for the dynamics in the economy. The existence of sunk entry costs, time–to–build lag, as well as adjustment costs implies that the number of firms constitutes an endogenous state variable. That is the reason why we do not observe an immediate jump in n but a smooth transition to its post–deregulation equilibrium level. As more and more competitors enter the market for intermediate goods, firm profits decline. Consequently, the dominance of the portfolio expansion effect over the profit destruction externality fades away, and firm value and hence investment in entrants converge to their new steady states.

Reduced monopoly power of banks pushes down the loan interest rate on impact.[18] In contrast, entrepreneurs cannot immediately adjust their demand for credit to the post–deregulation steady state level, although external finance

[18]Remember that the lending rate as well as bank capital and deposit interest rate are endogenous state variables. Accordingly, these variables do not react at time zero in Figure 2.4, but with a one–period lag.

Figure 2.4: Selected Impulse Responses to Banking Deregulation II



has become more attractive. Interestingly, the impulse response of bank loans resembles the smooth transition path of the number of firms. This co–movement of loan demand and portfolio size can be attributed to the borrowing limit faced by investors. The expansion of the firm portfolio gradually loosens the borrowing constraint, because (i) the debt–to–income ratio increases, such that more future income can be pledged as collateral, and (ii) total dividend earnings go up, as the rise in the number of firms exceeds the decline in individual profits.[19] Furthermore, since the borrowing limit prevents business owners from obtaining their desired loan volume in the short–run, they are willing to cut consumption initially

[19] At this point it is intuitive to consider the complementary slackness condition for the borrowing constraint (2.17) in log–linearised form:

$$\underbrace{\widehat{\kappa_t} + \widehat{n_t}}_{\text{Increase in DTI ratio}} \quad + \quad \underbrace{\widehat{n_{t+1}} + \mathrm{E}_t[\widehat{\pi^F_{t+1}}]}_{\text{Increase in total dividends}} \quad = \frac{r^b}{1+r^b}\widehat{r^b_{t+1}} + \widehat{b_{t+1}},$$

where hatted variables denote log–deviations from steady state. The loan interest rate falls immediately and remains at low levels during the transition. Hence, the upgrade of the DTI ratio and the rise in dividend earnings translate into an increase in bank loans.

in order to mobilise additional funds for firm creation.

Private households anticipate that bank profits and dividends will be permanently lower in the future. As a result, the share price of the mutual fund plummets, which drives up its return in the short–run. No arbitrage requires that a higher return on risky stocks is associated with a lift in the interest rate on safe bank deposits. The increase in the deposit interest rate dominates the gradual rise in bank loans, such that marginal benefit of bank capital diminishes on impact. Since marginal costs remain unchanged, bank equity must fall.[20] During the transition to the new equilibrium, bank assets increase gradually, whereas the return on deposits declines. As a consequence, the initial drop in the marginal benefit of bank capital vanishes over time and bank equity converges back to its old steady state. After all, the capital ratio falls due to the expansion of the bank balance sheet.

2.4.3 Empirical Evidence

At a first glance, the predictions of the model are qualitatively concurrent with empirical evidence on US intra– and interstate banking deregulation. Consistent with findings in previous studies, the model suggests (i) an increase in the number of incorporations and firm entrants (see Black and Strahan (2002), Cetorelli and Strahan (2006), and Kerr and Nanda (2009)), (ii) a reduction of the average size of non–financial firms (see Cetorelli and Strahan (2006)), (iii) a fall in interest rate spreads (see Dick (2006)), due to a decline in borrowing interest rates, while deposit interest rates remain unchanged (see Jayaratne and Strahan (1998)), as well as (iv) a positive effect on employment, output and personal income (see Beck *et al.* (2010) and Jayaratne and Strahan (1996)).

The model also forecasts a strong increase in bank credit supply after deregu-

[20]Recall the first–order condition with respect to bank capital in equation (2.23). The log–linearised version of this condition is

$$\widehat{k^B_{t+1}} = \frac{\theta_1}{1+\theta_1}\left(\widehat{b_{t+1}} - \widehat{b_t}\right) - \frac{\beta(1-\beta)}{1+\theta_1}\frac{1-\delta^B}{1-\beta(1-\delta_B)}\widehat{r_{t+1}}.$$

The change in bank loans $\left(\widehat{b_{t+1}} - \widehat{b_t}\right)$ weighted by the factor $\frac{\theta_1}{1+\theta_1}$ is smaller than the increase in the interest rate $\widehat{r_{t+1}}$ multiplied by the factor $\frac{\beta(1-\beta)}{1+\theta_1}\frac{1-\delta^B}{1-\beta(1-\delta_B)}$. Accordingly, the initial increase in the deposit interest rate predominates the effect of higher bank loans, such that bank equity declines.

lation. This finding is in line with a recent study by Dick and Lehnert (2010) who argue that the removal of bank entry restrictions was followed by a considerable expansion in bank lending. On the contrary, Jayaratne and Strahan (1996) find no significant change in the volume of bank loans, whereas the quality of loan portfolios has improved. The model implied rise in bank assets is though consistent with Calem (1994) who documents larger average bank size in the aftermath of the reform.

It is not surprising that financial liberalisation in the model is associated with a sharp decline in bank profits. After all, banks in my theoretical economy are rather stylised since they only make money through charging a mark–up on loan interest rates, which is substantially lower after deregulation. This prediction seems to be at odds with what we observe in the data. For instance, Jayaratne and Strahan (1998) show that the removal of branching restrictions led to a slight but insignificant increase in the profitability of commercial banks. Similarly, Dick (2006) finds that the passage of the IBBEA had no impact on bank profits.[21]

2.5 Empirical Evaluation of the Model

The previous section provided insights on how bank market integration affects certain economic variables. As I have shown, the model indeed succeeds in explaining several empirical facts. However, the analysis so far leaves the question of whether my theoretical framework can also account for the effect of banking deregulation on macroeconomic dynamics, such as the stabilisation of business cycle fluctuations or improved risk sharing.

In this section, I will scrutinise the empirical validity of the model in a more elaborate manner. To do so, I apply a state–specific calibration of the model in order to control for heterogeneity among US federal states. I simulate the model for each state to construct model generated panel data and reproduce various

[21] Interestingly, bank earnings have not been strongly affected although margins on lending have dropped significantly. This suggests that financial institutions have expanded their activities to more profitable areas. As market power of banks has declined, traditional financial intermediation has become less attractive. This change has induced banks to adjust their business models. Indeed, over the last decades financial institutions have increasingly focussed on the creation and trade of more complex financial products and switched their operations to more risky, fee–based, and non–interest services (see Gambacorta and Marques-Ibanez (2011)).

regression exercises implemented in previous studies. In this vein, I try to bridge the gap between my theoretical framework on the one hand, and the empirical approach followed by the existing literature on the other.

2.5.1 Data Generation

The prohibition of intra– and interstate banking in the US was imposed by a multitude of different state and federal laws. As a consequence, the relaxation of geographical barriers to bank expansion across states occurred at different points in time. This cross–sectional and time variation in liberalisation made it convenient for researchers to examine the effects of the banking reform through panel regressions. On this account, I treat my theoretical framework as the data generating process and simulate the model 500 times for each of the 50 US states and the District of Colombia. I therefore obtain 500 panel data sets covering 51 states in the cross–section over the period from 1930 to 2010. This ensures that I have roughly as many pre– as post–deregulation observations. For each state, I use the model of the pre–deregulation era to generate data until the year in which statewide branching via mergers and acquisitions was allowed. From that year onwards, I switch to the post–deregulation economy setup.[22]

2.5.2 Firm Entry and Size

Let us first consider to what degree the regime switch affects investment in new firms and the size of a producer. Of course, I have already discussed the impact of deregulation on firm entry and firm size in Section 2.4. But to facilitate comparison with the existing literature, I also perform a regression exercise for these variables as it has been done by previous studies. In particular, I follow Kerr and Nanda (2009) and implement the simple reduced–form panel regression

$$Y_{s,t} = \alpha_s + \alpha_t + \beta \cdot D_{s,t} + \epsilon_{s,t}, \qquad \text{for} \quad s = 1, \ldots, 51, \tag{2.36}$$

[22] Of course, it does not matter at all whether I use the year of intra– or interstate deregulation to date the regime switch in the simulation. Here, I have chosen the year of *intrastate* deregulation.

where $Y_{s,t}$ is the dependent variable of interest in state s and year t, and stands for the logs of the number of firm entrants n_e, the total number of firms n, or the size of an individual firm, measured by its production volume k, respectively. α_s and α_t denote dummy variables, which control for state and time fixed effects. $D_{s,t}$ is an indicator variable, which takes the value 1 from the year in which the state deregulates and 0 otherwise, and $\epsilon_{s,t}$ is the error term. Hence, the coefficient β determines by how much the respective dependent variable changes, once a state lifts its branching restrictions.

Since, I estimate equation (2.36) using each model generated panel data set, I end up with 500 different estimation results for each specification in (2.36). Table 2.3 documents the regression output associated with the median estimate for the β coefficient in front of the deregulation dummy. To get an idea of how disperse the estimation results are, I also report the 10^{th} and 90^{th} percentile of the estimates in brackets.

From the discussion in Section 2.4, we expect increased firm creation and smaller firm size in the aftermath of financial liberalisation. Reassuringly, this is indeed what Table 2.3 reveals. The estimate of the median slope coefficient on the deregulation dummy is significant at the 1% level in all regressions. In the model for firm entrants, the lower and upper percentiles of the β coefficient range from 4.15 percent to 11.07 percent. Results are similar if we look at the logarithm of total firm number as dependent variable. In this specification, the 10^{th} and 90^{th} percentile of the estimate is 5.55 percent and 9.46 percent, respectively.

As a matter of fact, these findings mirror the results reported by the empirical literature. Examining data from Dun and Bradstreet (D&B), Black and Strahan (2002) show that the removal of intra– and interstate branching restrictions led to an increase in the number of new business incorporations per capita by 3.8 percent and 7.9 percent, respectively. Likewise, Cetorelli and Strahan (2006) report a rise in the number of external finance dependent manufacturing establishments by 11.6 percent after the transition to state– and nationwide banking was completed. As a comparison, Kerr and Nanda (2009) find that the relationship between banking liberalisation and business creation is weaker. Using data from the Longitudinal Business Database (LBD), they show that the total number of

Table 2.3: Impact of Banking Deregulation on Firm Entry and Size

	Dependent Variables		
	(I) Firm Start–ups	(II) Total Firm Number	(III) Firm Size
Deregulation	7.44***	7.50***	–7.31***
	(3.43)	(15.00)	(15.22)
	[4.15* / 11.07***]	[5.55*** / 9.46***]	[–9.12*** / –5.42***]
R^2	0.32	0.89	0.90
State Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Observations	6,630	6,630	6,630
Simulations	500	500	500

Notes: Table reports the results of the fixed effects panel regressions $Y_{s,t} = \alpha_s + \alpha_t + \beta \cdot D_{s,t} + \epsilon_{s,t}$, for $Y = \{\log(n_e), \log(n), \log(k)\}$. The dependent variables in model (I), (II), and (III) are the logs of new firm start–ups, total number of firms, and firm size, respectively. Regression output in each specification presents the results associated with the median estimate of the β coefficient in front of the deregulation dummy. The values in brackets correspond to the 10^{th} and 90^{th} percentile of the estimates for the β coefficient. Slope coefficients are multiplied by 100. Absolute values of t–statistics are in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

firm start–ups increased by only 6 percent after interstate banking was permitted, whereas intrastate deregulation had virtually no effect.

Finally, column (III) in Table 2.3 indicates that the simulated model somewhat understates the effect on firm size. Output volume of intermediate good producers decreases by about 7.3 percent at the median after deregulation. In a recent paper, Cetorelli and Strahan (2006) use the number of employees in manufacturing establishments as a proxy for the size of production sites. They show that the average size of external finance dependent establishments has shrunk by as much as 12.3 percent relative to external finance independent establishments after the relaxation of all geographical branching restrictions.[23]

2.5.3 Business Cycle Volatility

Next, I explore in how far my model helps to understand the relationship between financial liberalisation and macroeconomic volatility. To measure the impact of

[23] Similar effects of financial liberalisation can be found for the European Union (EU). Cetorelli (2004) shows that increased bank competition after the passage of the *Second Banking Coordination Directive* in 1993, which allowed banks to branch freely across the EU, has led to less concentration and reduced average firm size in non–financial sectors.

bank market integration on state business cycle volatility, I adopt the approach of Morgan *et al.* (2004). Again, I perform fixed effects panel regressions of the simple form:

$$Y_{s,t} = \alpha_s + \alpha_t + \beta \cdot D_{s,t} + \epsilon_{s,t}, \qquad \text{for} \quad s = 1, \ldots, 51. \tag{2.37}$$

The dependent variable $Y_{s,t}$ is the fluctuation of the growth rate of output, income of private households, or income of entrepreneurs, respectively. Fluctuations are determined by the absolute deviation from the conditional mean growth of the corresponding variable. To estimate conditional mean growth rates, I run the auxiliary regression

$$\Delta \log(X_{s,t}) = \gamma_s + \gamma_t + \delta \cdot D_{s,t} + \eta_{s,t}, \qquad \text{for} \quad s = 1, \ldots, 51, \tag{2.38}$$

where $X_{s,t}$ equals output, household labour income, and entrepreneurial portfolio income, respectively, in state s at time t. In words, the conditional mean growth rates are fitted by regressing first differences in logs of each variable on state fixed effects γ_s, time fixed effects γ_t, and the deregulation dummy $D_{s,t}$. Thus, growth fluctuations in equation (2.37) can be calculated by the absolute value of the residuals in auxiliary regression (2.38), i.e.

$$Y_{s,t} = |\eta_{s,t}|. \tag{2.39}$$

Results are displayed in Table 2.4. My findings support the notion that banking deregulation leads to a stabilisation of variations in output and income growth. The coefficient on the deregulation dummy enters highly significant in all regressions. The estimated effects are also economically sizeable. Column (I) presents the results for output growth fluctuations. The removal of entry restrictions in the banking industry reduces output growth volatility by about 0.2 to 0.3 percentage points. The effect is even stronger if we look at income volatility of households and entrepreneurs in columns (II) and (III). Evidently, entrepreneurs are not only the main beneficiaries from a liberalisation of the banking sector due to lower borrowing costs but also in terms of reduced variability of their portfolio income. The median estimate of the β coefficient is –1.1244 in the regression for entrepreneurial income growth variations compared to –0.6504 for labour income growth variations.

In a nutshell, estimation results in Table 2.4 closely reflect the empirical findings in Morgan *et al.* (2004). Their analysis shows that the transition to inter– and intrastate branching reduced growth fluctuations of the gross state product by 0.6 and 0.2 percentage points, respectively. This effect is a bit stronger than my simulated economy suggests. Regarding the volatility of personal income growth, they report a decline by 0.5 (0.1) percentage points after interstate (intrastate) deregulation, which is very close to the estimates I obtain in the regression for labour income fluctuations.

How can we explain the moderation of the business cycle followed by the liberalisation of the banking market? In principle, the influence of deregulation on economic volatility in the model is ambiguous. Banking deregulation changes the propagation of shocks in different ways. For instance, consider a positive transitory shock to bank competition. An increase in the elasticity of substitution between loans temporarily pushes down the borrowing interest rate, which induces entrepreneurs to expand their demand for credit and to increase investment new firms. As described above, enhanced firm entry translates into higher income and consumption for both entrepreneurs and households. However, it is important to note that after the banking reform, the steady state level of the borrowing interest rate is lower. This implies that the relative drop in r^b is smaller, which curbs the effect on lending, investment, income, and consumption.

A similar line of reasoning applies if we look at a shock to labour–augmenting technology. As productivity of workers goes up, firm production and profits increase. This creates incentives for investors to finance new firm start–ups. Recall from Section 2.4 that banking deregulation leads to a permanent fall in the shadow value of an additional producer. Intuitively, an entrepreneur's marginal benefit of funding new firm entrants is lower compared to the pre–deregulation era, which attenuates the portfolio expansion effect induced by the positive productivity shock. That means that the relative increase in investment is muted and so is the respective rise in income and consumption.

In contrast, the effects of a collateral shock become more pronounced once the

Table 2.4: Impact of Banking Deregulation on State Business Cycle Fluctuations

	Dependent Variables		
	(I) Output Fluctuations	(II) HH Income Fluctuations	(III) Entr. Income Fluctuations
Deregulation	–0.2657***	–0.6504***	–1.1244***
	(4.8768)	(8.6080)	(8.2025)
	[–0.3351*** / –0.1901***]	[–0.7587*** / –0.5180***]	[–1.2873*** / –0.9181***]
R^2	0.0742	0.1416	0.1370
State Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Observations	6,579	6,579	6,579
Simulations	500	500	500

Notes: Table reports the results of the fixed effects panel regressions $Y_{s,t} = \alpha_s + \alpha_t + \beta \cdot D_{s,t} + \epsilon_{s,t}$. The dependent variables in model (I), (II), and (III) are growth fluctuations of output, household labour income, and entrepreneurial portfolio income, respectively. Fluctuations are determined by the absolute deviation from conditional mean growth in the corresponding variable. Regression output in each specification presents the results associated with the median estimate of the β coefficient in front of the deregulation dummy. The values in brackets correspond to the 10^{th} and 90^{th} percentile of the estimates for the β coefficient. Slope coefficients are multiplied by 100. Absolute values of t–statistics are in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

banking industry is more competitive. A positive shock to κ lifts the borrowing limit since banks are more willing to accept future portfolio earnings as collateral. As a consequence, loan demand and investment of entrepreneurs go up. The fact that credit is permanently cheaper after the regime switch actually reinforces the increase in borrowing, such that the rise in bank credit and firm entry is stronger relative to the pre–deregulation economy.[24]

In the present calibration exercise, the mitigated effects of productivity and bank competition shocks after the reform outweigh the amplified responses associated with disturbances in the collateral value. Thus, the predominance of

[24]This effect becomes more clear if we reconsider the complementary slackness condition for the borrowing constraint (2.17) in log–linear form:

$$
\begin{aligned}
&\widehat{\kappa_t} + \widehat{n_t} + \widehat{n_{t+1}} + \mathrm{E}_t[\widehat{\pi^F_{t+1}}] = \frac{r^b}{1+r^b}\widehat{r^b_{t+1}} + \widehat{b_{t+1}} \\
\overset{(2.22)}{\iff}\quad &\widehat{\kappa_t} + \widehat{n_t} + \widehat{n_{t+1}} + \mathrm{E}_t[\widehat{\pi^F_{t+1}}] = \left(\frac{r\epsilon}{(\epsilon-1)(1+r^b)} + \Lambda\right)\widehat{r_{t+1}} - \Lambda(1+r)\widehat{b_t} \\
&\qquad + (1+2\Lambda)\widehat{b_{t+1}} - \Lambda \mathrm{E}_t[\widehat{b_{t+2}}] - (1+r)\Lambda\widehat{k^B_{t+1}} + \Lambda \mathrm{E}_t[\widehat{k^B_{t+2}}],
\end{aligned}
$$

where $\Lambda \equiv \frac{\epsilon}{(\epsilon-1)(1+r^b)}\frac{\theta_0\theta_1^2}{b}\left(\frac{1}{k^B}\right)^{\theta_1}$. Note that factor Λ is lower after deregulation. Hence, changes in the collateral shock variable κ, *ceteris paribus*, lead to stronger reactions in the demand for loans.

technology and bank competition shocks in driving the dynamics of the model accounts for the overall stabilisation of the business cycle.

In light of that, bank market integration may have contributed to the significant drop in aggregate economic volatility in the United States over the 1980s and 1990s. This phenomenon has become known as the "Great Moderation".[25] Yet the Great Recession of 2008–2009 has led to the impression that the Great Moderation is finally over. Note, however, that the resurgence in macroeconomic volatility in recent years still might be consistent with the implications of my model. On the one hand, we can think of the last two decades of the twentieth century as a period in which disturbances to productivity and bank competition were the driving forces behind macroeconomic fluctuations. This explains the empirically observed stabilisation of the business cycle after deregulation. On the other hand, collateral shocks might have become more important in recent years, such that economic volatility has actually increased again. In fact, Goodfriend and McCallum (2007) interpret the occurrence of financial distress, like during the financial crisis of 2008, as the result of large negative shocks to the collateral value.

2.5.4 Risk Sharing

Lastly, I examine the impact of banking deregulation on risk sharing. Economic agents in my model face substantial income uncertainty over the business cycle. They benefit from high income in booms, but suffer from lower endowment during recessions. The services provided by banks, however, allow agents to buffer their consumption against income shocks. In particular, households and entrepreneurs can transfer cash flows across time through the trade of non–contingent financial assets in form of sight deposits and loans, respectively. Having shown that banking deregulation reduces macroeconomic volatility, it is now natural to ask whether financial liberalisation can also help agents to better diversify their

[25]There exists a huge literature on the potential sources of the Great Moderation. Among the most prominent explanations are a better conduct of monetary policy by the Federal Reserve (see Clarida *et al.* (2000) and Boivin and Giannoni (2006)), improved inventory management (see McConnell and Perez-Quiros (2000)), good luck in form of absent or smaller economic shocks (see Stock and Watson (2002) and Blanchard and Simon (2001)), or a decline in the volatility of shocks (see Justiniano and Primiceri (2008)).

consumption risk.

To test how deregulation affects consumption risk sharing, I build on the empirical model described in Hoffmann and Shcherbakova-Stewen (2011):[26]

$$\Delta\widetilde{c_{s,t}^k} = \alpha_s + \alpha_t + \beta_1 \cdot \Delta\widetilde{y_{s,t}} + \beta_2 \cdot D_{s,t} + \beta_3 \cdot \Delta\widetilde{y_{s,t}} \cdot D_{s,t} + \epsilon_{s,t}, \qquad \text{for } k = \{H, E\}, \quad (2.40)$$

where variables with a tilde denote log–deviations from the average across all states. That is, $\Delta\widetilde{c_{s,t}^H} \equiv \Delta \log\left(\frac{c_{s,t}^H}{c_t^H}\right)$, $\Delta\widetilde{c_{s,t}^E} \equiv \Delta \log\left(\frac{c_{s,t}^E}{c_t^E}\right)$, and $\Delta\widetilde{y_{s,t}} \equiv \Delta \log\left(\frac{y_{s,t}}{y_t}\right)$, where c_t^H, c_t^E, and y_t stand for the national average of per capita household consumption, entrepreneurial consumption, and output, respectively. Again, α_s and α_t control for state and time fixed effects, $D_{s,t}$ is the deregulation dummy variable, and $\epsilon_{s,t}$ is the error term.

In equation (2.40), I regress $\Delta\widetilde{c_{s,t}^k}$ on state output growth relative to the mean growth in the cross–section instead of relative household or entrepreneurial income growth. In the theoretical economy, output equals total income (see equation (2.33)) and output changes are associated with direct endowment changes for both groups of agents. Hence, the specification in regression (2.40) serves as a convenient approach to assess the risk sharing pattern in the model. The fact that output is highly correlated with personal income also explains why I focus on consumption risk sharing rather than income insurance. Per construction, individuals cannot hedge their labour or capital income stream against state–specific business cycle shocks, such that an analysis of income risk sharing would not be very enlightening. Besides, it is changes in consumption and not income that determines how severely people are affected by economic up– and downturns. In this vein, the choice of relative consumption growth as dependent variable appears to be more reasonable.

As Hoffmann and Shcherbakova-Stewen (2011) point out, panel regressions of this form have become very popular in empirical macroeconomic research on financial market completeness. In this setup, the coefficient β_1 usually takes on a value between 0 and 1 and captures the impact of state income growth on

[26]Contrary to my analysis here, Hoffmann and Shcherbakova-Stewen (2011) mainly focus on how intrastate deregulation affected the procyclicality of consumption risk sharing. They find that interstate risk sharing has become less procyclical after the reform.

state consumption growth. Therefore, we can easily interpret β_1 as the fraction of state–specific, or idiosyncratic, output risk that is uninsured. In theory, all idiosyncratic risk can be diversified away if financial markets are complete, i.e. trade of state contingent Arrow–Debreu securities is possible. In this case, perfect risk sharing is achieved and consumption growth is independent of state level business cycle risk, i.e. $\beta_1 = 0$. Primary interest of my analysis lies in the magnitude of the coefficient β_3 in front of the interaction between the deregulation dummy and state output growth relative to average nationwide output growth. This coefficient measures the (negative) change in consumption insurance once a state lifts its bank entry restrictions. To be more precise, β_1 determines the share of non–diversified idiosyncratic risk *before* deregulation, whereas $(\beta_1 + \beta_3)$ measures the share of uninsured risk *after* deregulation. If deregulation leads to improved risk sharing, the relationship between state level income changes and consumption growth will be weaker, so that $\beta_3 < 0$.

Table 2.5 shows the estimation results of this exercise. Here, I present the regression output accompanied with the median estimate of the β_3 coefficient on the interaction term. As before, numbers in brackets refer to the 10^{th} and 90^{th} percentile of the respective estimated coefficient.

Let us first consider the pattern of consumption risk sharing of private households, summarised in column (I). The estimate of the coefficient on $\Delta\widetilde{y_{s,t}}$ associated with the median estimate of β_3 is 0.2667 and significant at the 1% level. This means that prior to deregulation, roughly one quarter of idiosyncratic output risk cannot be hedged through trade of financial securities. Interestingly, this figure is fairly close to its empirical counterpart. For instance, based on annual state level data on US per capita consumption and output over the period 1963–2005, Hoffmann and Shcherbakova-Stewen (2011) report an estimate of about 0.2. More importantly, my estimation results suggest that consumption risk sharing of private households does not change once the banking sector becomes liberalised. Estimates of the β_3 coefficient are close to zero and mostly statistically insignificant.

Turning to consumption risk of entrepreneurs, we see that the picture is clearly different. As is evident from column (II) in Table 2.5, consumption insurance of investors is far from perfect. Estimates of the β_1 coefficient are as high as

Table 2.5: Impact of Banking Deregulation on Consumption Risk Sharing

	Dependent Variables	
	(I)	(II)
	Household Consumption	Entrepreneurial Consumption
$\Delta\widetilde{y_{s,t}}$	0.2667***	0.6151***
	(15.5950)	(34.3231)
	[0.2915*** / 0.2632***]	[0.6444*** / 0.6051***]
$D_{s,t}$	–0.0023***	–0.0019**
	(1.9649)	(2.2326)
	[–0.0020** / –0.0011]	[–0.0011 / –0.0015*]
$\Delta\widetilde{y_{s,t}} \cdot D_{s,t}$	–0.0312	–0.1578***
	(0.3343)	(4.6010)
	[–0.0711** / 0.0057]	[–0.2021*** / –0.1174***]
R^2	0.0793	0.2712
State Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Observations	6,579	6,579
Simulations	500	500

Notes: Table reports the results of the fixed effects panel regressions $\Delta\widetilde{c^k_{s,t}} = \alpha_s + \alpha_t + \beta_1 \cdot \Delta\widetilde{y_{s,t}} + \beta_2 \cdot D_{s,t} + \beta_3 \cdot \Delta\widetilde{y_{s,t}} \cdot D_{s,t} + \epsilon_{s,t}$, for $k = \{H, E\}$. The dependent variables in model (I) and (II) are first differences of the log–deviations of household and entrepreneurial consumption per capita from their national averages, respectively. Regression output in each specification presents the results associated with the median estimate of the β_3 coefficient in front of the interaction term between log–deviation of state output from average output and the deregulation dummy. The values in brackets correspond to the 10$^{\text{th}}$ and 90$^{\text{th}}$ percentile of the estimates for the corresponding coefficient. Absolute values of t–statistics are in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

0.6 and significant at the 1% level. This implies that entrepreneurs can only hedge around 40 percent of state–specific business cycle risk before the regime switch.[27] However, the regulatory change in banking brings about a considerable improvement in risk sharing of investors. As a matter of fact, deregulation reduces the share of uninsured idiosyncratic shocks by about 16 percentage points at the median. This effect is not only economically sizeable but also highly significant throughout all regressions.

Estimation results for the simulated economy are to some extent in line with findings of the empirical literature. For instance, Demyanyk *et al.* (2007) show that the permission of state– and nationwide banking had a positive impact on

[27] The model proposes that risk sharing is much lower for entrepreneurs than for private households. In fact, this prediction can be supported empirically. For example, Agronin (2003) analyses income risk sharing across US states over the period 1963–1999. He shows that proprietorial income risk is substantially less diversified than non–proprietorial income risk.

personal income insurance. On average, banking deregulation increased the portion of diversified idiosyncratic shocks by around 10 percentage points. The effect is even more pronounced in states where small businesses are relatively important. In these states income risk sharing improved by about 20 percentage points. This observation can be attributed to the importance of bank finance for small enterprises and the close link between personal income of firm owners and firm profits. Furthermore, bank market integration markedly reduces the sensitivity of proprietorial income to state–specific business cycle shocks. As a consequence, it is especially proprietors, or equivalently, entrepreneurs in my theoretical economy, who enjoy better diversification following the regime switch.

What is more, Hoffmann and Shcherbakova-Stewen (2011) find no evidence that deregulation altered the level of average consumption risk sharing. This result can be consistent with the prediction of my model. The fact that only entrepreneurs but not private households can better hedge their consumption risk after financial liberalisation suggests that the effects may cancel out, so that we observe no change in consumption risk sharing on average.

This leaves us with one question: Why does the model predict an increase in risk sharing of entrepreneurs, whereas private households cannot benefit from enhanced insurance after deregulation? The degree to which agents can hedge macroeconomic risks depends on the type and availability of financial assets. Prior to deregulation, high borrowing costs hamper investors' access to external finance. Expensive credit effectively limits the potential of entrepreneurs to smooth consumption over time, such that income fluctuations largely translate into consumption changes. Financial liberalisation permanently decreases loan interest rates and eases the collateral constraint, which ameliorates borrowing opportunities. As a result, risk sharing increases since entrepreneurs can better buffer consumption against changes in their portfolio income. In principle, we can think of bank market integration as improving insurance, because financial intermediaries now partly absorb the firm portfolio income risk of entrepreneurs. Conversely, deregulation does not permanently affect deposit interest rates. In other words, financial trading conditions for private households remain unchanged and hence they do not enjoy better diversification.

2.6 Conclusion

Empirical research on the economic effects of the relaxation of US intra– and interstate banking limitations has been very active. What is striking, however, is that theoretical work on this issue has been rather limited. My paper aims at contributing to filling this gap and analyses the macroeconomic implications of banking deregulation from a theoretical perspective. I present a DSGE model with financial frictions and endogenous firm entry that helps to understand the interaction between banking and the real side of the economy. The model emphasises the essential role of financial intermediation for economic activity. Banks provide plain vanilla financial services: they collect sight deposits from private households, accumulate equity through retained earnings and supply loans to entrepreneurs. The financial system is characterised by monopolistic competition in the credit market. Consequently, banks exploit their market power and charge a high premium on loan interest rates. Financial deregulation spurs competition in the banking sector and thus ameliorates credit market access of entrepreneurs.

A key contribution of my analysis is how I link my theoretical framework to the existing empirical literature. I apply a state–specific calibration of the model and generate panel data, which I then use to perform various regression exercises similar to those implemented in related studies. The model is able to explain various empirical findings. In particular, it predicts that financial liberalisation leads to an increase in firm creation, a decline in average firm size, an erosion of the bank capital ratio, lower state business cycle volatility, and an improvement of entrepreneurial risk sharing.

The events of the recent financial crisis have stressed the need for incorporating more sophisticated financial sectors in dynamic macro models. Banking in my setup is rather stylised. All investors are identical and there is no risk of default. No matter what state of the world occurs, creditors pay back the full amount of their debt. Financial intermediaries have only one type of assets in their balance sheets which is totally safe. This is tantamount to saying that banks cannot fail and stability of the financial system is always granted. Of course, this assumption is a strong simplification of the real world. Hence, it would be interesting to extend the framework along this dimension and study the impact of deregulation on the riskiness of financial institutions.

Nevertheless, this paper is a stark reminder of the potential benefits associated with free banking. Today, we call for tougher regulation of the financial industry to avoid the recurrence of a global financial meltdown. No doubt, reforming our financial system is inevitable. Nevertheless, policymakers and regulators should not forget the merits of liberal financial markets when they redefine the regulatory environment for banks.

Chapter 3

Business Cycles in Emerging Markets: the Role of Liability Dollarisation and Valuation Effects

3.1 Introduction

Over the last twenty years, the world economy has witnessed a growing importance of Emerging Market Economies (EMEs). While their share of global output at purchasing power parity was about 30 percent in 1990, it has risen to more than 50 percent by 2013 according to the International Monetary Fund (IMF).[1] As a consequence, EMEs have increasingly influenced the global business cycle and are catching up to the rich world at a remarkable pace. What is striking, however, is that business cycles in these countries reveal noticeably different patterns compared to developed economies. This naturally raises the questions of why do we observe these discrepancies.

In recent years, considerable attention in research on international macroeconomics has been devoted to understanding business cycle fluctuations in EMEs. Many researchers have documented certain empirical regularities among these countries (see Neumeyer and Perri (2005), Aguiar and Gopinath (2007), and García-Cicco *et al.* (2010)). First, EMEs are generally exposed to more severe business cycle fluctuations than developed economies. Second, EMEs have strongly countercyclical net exports and their international capital inflows are subject to so–called "sudden stops" (see Calvo (1998), Calvo and Reinhart (2000), and Men-

[1]See *The Economist*, article "When giants slow down", July 27th, 2013.

doza (2010)). Third, consumption volatility exceeds income volatility.[2]

This paper develops a Dynamic Stochastic General Equilibrium (DSGE) model of a small open economy (SOE) to address these business cycle phenomena and the importance of credit market imperfections in EMEs. The basic structure of our framework goes back to the workhorse SOE real business cycle (RBC) model of Mendoza (1991). We build on Aguiar and Gopinath (2007) and introduce a permanent productivity shock in addition to a conventional transitory productivity shock in our theoretical economy. Moreover, we contribute to the existing RBC literature on emerging markets by featuring differentiated home and foreign goods as well as exogenous foreign demand shocks in our model. In this vein, we also incorporate endogenous real exchange rate fluctuations in our setup.

As Chari *et al.* (2007) point out, one can think of the non–stationary technology component as efficiency wedge which captures various forms of market distortions. Nevertheless, since our analysis aims at investigating the role of specific financial frictions in emerging market business cycles we also augment our framework along this dimension. In particular, similar to García-Cicco *et al.* (2010) we introduce credit market imperfections in form of a debt–elastic country premium on the interest rate. Indeed, this reduced form financial friction is a convenient way to account for a positive link between higher external indebtedness and borrowing costs, which seems to be empirically plausible (see Uribe and Yue (2006) or Arellano (2008)).

More importantly, a major contribution of our work is that we also analyse the phenomenon of *liability dollarisation* as a further form of financial frictions in our framework.[3] Emerging markets have traditionally depended heavily on external funds in form of short–term debt to finance their growth opportunities (see Kose and Prasad (2010)). In contrast to advanced economies, however, international capital market imperfections have impeded EMEs to issue debt denoted in their own currency. As a result, these countries have held the bulk of their external debt in major international currencies such as US dollars. The inability of borrowing

[2]Another salient characteristic of emerging market business cycles is that real interest rates tend to be countercyclical, very volatile and lead the cycle (see Neumeyer and Perri (2005) and Uribe and Yue (2006)). This feature, however, is not subject of the analysis in this paper.

[3]The term "liability dollarisation" was coined by Calvo (2001).

abroad in domestic currency faced by emerging markets, which Eichengreen *et al.* (2005) refer to as the "Original Sin" phenomenon, is a well–known fact and has been documented in a number of previous studies (see Reinhart *et al.* (2003b), Eichengreen and Hausmann (2005), and Lane and Shambaugh (2010)).[4] Our paper does not investigate the reasons behind liability dollarisation in emerging markets, but studies its implications. To this end, we extend our benchmark model and assume that the small open economy can only borrow in foreign currency.

In our empirical exercise, we apply a mixture of country–specific calibration and Bayesian estimation. Related studies have predominantly investigated particular emerging markets and partly tried to derive conclusions for EMEs in general. However, given the fact that EMEs share the aforementioned stylised business cycle features, we think it is crucial to expand the analysis to a broader selection of countries and thus also allow for potential heterogeneity. Therefore, we study the cases of Mexico, South Africa, and Turkey. Besides, we additionally estimate our benchmark model for a cohort of developed countries, namely Canada, Sweden, and Switzerland. This enables us to confront the results obtained for emerging and advanced economies.

To estimate our models, we take real time series data on output, consumption, interest rates, and exchange rates. A substantial contribution of our work is how we capture off–model dynamics in our estimation. In particular, we follow Sargent (1989) and Ireland (2004) by including a (vector–)autoregressive measurement error component. To our knowledge, this has not been done yet in this strand of the literature and goes beyond the procedures applied by existing studies (e.g. García-Cicco *et al.* (2010) and Chang and Férnandez (2013)).

Estimation results show that financial frictions are generally more pronounced in EMEs than in industrialised countries, which is in line with the conclusion of García-Cicco *et al.* (2010). Besides, off–model dynamics appear to be of minor importance for the dynamics of macroeconomic aggregates in general. This result

[4]In recent years, several emerging markets have implemented various policies to tackle dollarisation. The process of dedollarisation is generally protracted and in most cases incomplete (see Kokenyne *et al.* (2010)). While some countries have been successful, others have failed to achieve persistent dedollarisation (see Reinhart *et al.* (2003a)). Nevertheless, our empirical analysis uses data from a period in which liability dollarisation was a prevalent feature of external finances in EMEs.

suggests that our model is capable of explaining a great deal of the variation in the data. Moreover, we show that for the group of EMEs, the model with liability dollarisation by and large outperforms the benchmark setup in capturing the dynamics in the variables we use for estimation. This outcome provides a strong argument in favour of the introduction of liability dollarisation in the model.

Our analysis suggests that the co–existence of financial market imperfections and trend shocks helps us to explain macroeconomic fluctuations in emerging markets. In EMEs, the transitory productivity process is the driving force behind output in the short–run, whereas non–stationary technology shocks determine income fluctuations in the long–run. Contrary to that, transitory productivity shocks determine output fluctuations over all horizons in developed economies. Hence, although we incorporate various financial frictions in our model, we still find support for the famous hypothesis by Aguiar and Gopinath (2007) that *"the cycle is the trend"* in emerging markets. That said, our findings contradict the conclusions of other studies which argue that this notion rests upon the absence of certain market distortions. For instance, García-Cicco *et al.* (2010) and Chang and Férnandez (2013) show that once one incorporates financial frictions in the framework, the permanent shock strongly loses importance. Likewise, a recent paper by Boz *et al.* (2011) studies a real business cycle model in which agents learn to differentiate between permanent and transitory disturbances. These authors argue that it is more severe informational frictions in EMEs that explain observed business cycle patterns even without a predominance of the non–stationary component in total factor productivity.[5]

Our work is also related to a currently active research area which highlights the importance of fluctuations in exchange rates and asset prices for a country's external balance sheet (see Tille (2003), Gourinchas and Rey (2007a), Gourinchas and Rey (2007b), Lane and Milesi-Ferretti (2007), and Gourinchas *et al.* (2010)).

[5] Nevertheless, the finding that trend shocks play a significant role for the business cycle can to some extent be supported by a closely related area of research in international macroeconomics. The literature on the empirics of the "intertemporal approach to the current account" highlights the importance of permanent shocks in explaining current account dynamics (see Glick and Rogoff (1995), Hoffmann (2001b, 2003), Kano (2008), and Corsetti and Konstantinou (2012)). In particular, Hoffmann and Woitek (2011) show that the world economy was predominantly characterised by permanent shocks in the period between World War I and World War II, exactly like today's emerging markets according to our findings.

These changes in the net foreign asset position, which are not due to capital flows, are called *valuation effects* and drive a wedge between the change in the net foreign asset position and the current account. Accounting for the fact that EMEs are not able to borrow on international markets in their own currency, our model yields further interesting insights with respect to the role of external balance sheet effects, which, though investigated in other areas (see Céspedes *et al.* (2004), Tille (2008), and Nguyen (2011)), has hitherto been unrecognised in this line of research. In particular, we find that valuation effects stabilise the change in the net foreign asset position induced by trend productivity shocks, whereas they amplify it after foreign demand shocks. In contrast, transitory technology shocks lead to valuation effects that may reinforce or mitigate the changes in the external balance sheet. Given that EMEs are characterised by a prevalence of trend shocks, we find that valuation effects act stabilising on average.

Furthermore, the model featuring liability dollarisation can account for various business cycle phenomena in EMEs. In particular, our model generates more severe macroeconomic fluctuations in EMEs than in advanced economies, and predicts a volatility of consumption that exceeds the one of output. Moreover, the model produces a countercyclical trade balance. But based on our estimation, it fails to quantitatively match the strong countercyclicality of net exports observed in the data. Finally, we show that the model succeeds in reproducing the reversal of capital flows to Mexico during the Tequila Crisis between 1994 and 1995.

The remainder of the paper is structured as follows. In the next section, we start with some descriptive business cycle statistics of selected countries and briefly discuss certain empirical features of valuation effects in EMEs. Section 3.3 outlines our benchmark model as well as the setup with liability dollarisation. In Section 3.4, we describe the data and introduce our calibration and estimation technique. Estimation results are presented in Section 3.5, while Section 3.6 discusses the dynamics of our model in greater detail. Some concluding remarks appear in Section 3.7.

3.2 Descriptive Analysis

Before we introduce our theoretical framework, which we later use to examine macroeconomic dynamics in EMEs, we take a look at some descriptive statistics first. We begin with illustrating the distinct empirical regularities about business cycles in EMEs contrary to industrialised countries. To this end, we calculate standard business cycle moments for numerous EMEs and compare them with those obtained for a group of developed small open economies. Subsequently, we document the stabilising impact of valuation effects on the external balance sheet in EMEs.

3.2.1 Business Cycle Features

The now well–established term "Emerging Market" was originally introduced by Antoine van Agtmael in 1981, describing developing countries that experience rapid economic progress and potentially catch up with developed economies (see Van Agtmael (2007)). Today, there exists a wide range of definitions of an emerging market and numerous different classifications. For that reason, we rely on three well–known classifications and focus our descriptive analysis on the so–called BRIC (Brazil, Russia, India, China) and CIVETS (Columbia, Indonesia, Vietnam, Egypt, Turkey, South Africa) countries as well as selected economies from the list of emerging markets compiled by the Dow Jones Indexes.

At this point, we use annual data from the International Financial Statistics (IFS) on output, consumption, exports, imports, and the real exchange rate.[6] For the real exchange rate we construct an index which we normalise to 100 in year 2005. To derive real per capita variables for output and consumption, we divide each series by population and subsequently deflate output using the GDP deflator, and consumption using the Consumer Price Index (CPI). To study business cycle fluctuations, we detrend all variables except for the net exports to output ratio. For this purpose, we apply the Hodrick and Prescott (1997) (HP) filter on logged

[6] We use real exchange rates vis–à–vis the US. The choice of annual rather than higher frequency time series enables us to investigate a longer time period. Nevertheless, we did the same exercise using quarterly data and found no qualitative differences in the results.

series with smoothing parameter 100.[7]

Descriptive sample statistics are displayed in Table 3.1. Various stylised business cycle facts are worth emphasising.[8] First, fluctuations in macroeconomic aggregates in EMEs are generally more pronounced than in developed economies. For instance, our selected countries on the Dow Jones list exhibit average standard deviations of output, consumption and net exports that are more than twice as high as in the group of industrialised economies. This salient feature is visualised in Figure 3.1, which plots the cyclical component of GDP for each country. The graph clearly demonstrates the excess business cycle volatility in emerging markets relative to advanced economies. Second, consumption volatility exceeds output volatility in EMEs, whereas the standard deviation of consumption is on average lower than that of output in developed countries. Third, the net exports to output ratio tends to be fairly countercyclical. For instance, the mean correlation of GDP and the net exports to output ratio is as much negative as -0.45 for the CIVETS countries. By contrast, advanced economies exhibit a rather weak link between these variables. In fact, our calculations yield a correlation of merely -0.04 on average.

Somewhat surprisingly, previous studies in this line of research have not put particular focus on the business cycle features of the real exchange rate. Table 3.1 indicates that there are differences between EMEs and advanced countries along this dimension, too. The real exchange rate is more volatile in emerging markets than in developed economies. Moreover, real appreciations are associated with a fall in the trade balance to GDP ratio in EMEs. The mean correlation between these variables is -0.36 across all EMEs. On the other hand, the link between net exports and real exchange rates appears to be much weaker in the group of developed economies, for which we find basically no correlation on average.

The empirical regularities documented here are very robust. Nevertheless, we also detect some minor differences within the cohort of emerging markets. For

[7] We are aware of the shortcomings of this filtering method. Hence, we also looked at first differences of the logged series as well as cubically detrended logged series to check the robustness of our findings. Indeed, business cycle moments seem to be rather insensitive with respect to the filter choice.

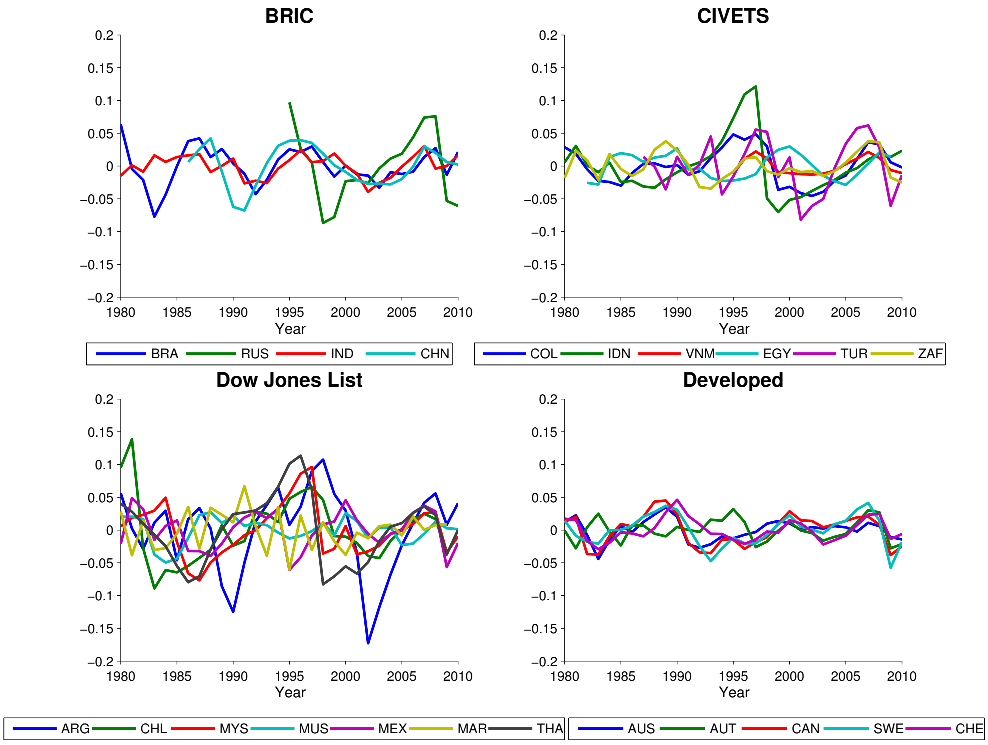
[8] We confidently call certain business cycle patterns as "stylised facts" because they have already been documented in a number of earlier studies. See, among others, Neumeyer and Perri (2005), Aguiar and Gopinath (2007), García-Cicco *et al.* (2010), and Kose and Prasad (2010).

Table 3.1: Business Cycles in EMEs and Developed Economies

	$\sigma(Y)$	$\sigma(C)$	$\sigma\left(\frac{NX}{Y}\right)$	$\sigma(e)$	$\frac{\sigma(C)}{\sigma(Y)}$	$\rho\left(\frac{NX}{Y},Y\right)$	$\rho\left(\frac{NX}{Y},e\right)$
BRIC							
Brazil (BRA)	2.93	12.17	2.42	21.67	4.16	−0.30	−0.37
Russia (RUS)	5.64	8.51	4.80	17.79	1.51	−0.28	−0.75
India (IND)	2.16	4.00	1.37	6.13	1.85	−0.13	−0.32
China (CHN)	3.11	3.55	2.76	7.85	1.14	0.08	0.00
Mean	3.46	7.06	2.84	13.36	2.17	−0.16	−0.36
CIVETS							
Colombia (COL)	2.65	4.70	3.44	11.50	1.78	−0.27	−0.50
Indonesia (IDN)	3.89	4.80	3.47	15.58	1.23	−0.37	−0.28
Vietnam (VNM)	1.29	2.15	4.15	6.46	1.67	−0.50	−0.54
Egypt (EGY)	1.88	2.83	4.07	22.57	1.51	−0.42	−0.54
Turkey (TUR)	4.11	6.10	2.81	9.99	1.49	−0.66	−0.68
South Africa (ZAF)	2.02	3.35	3.70	10.94	1.66	−0.47	−0.21
Mean	2.64	3.99	3.61	12.84	1.56	−0.45	−0.46
Dow Jones List							
Argentina (ARG)	5.67	10.32	3.75	30.96	1.82	−0.76	−0.29
Chile (CHL)	5.55	7.66	36.56	19.77	1.38	−0.26	0.09
Malaysia (MYS)	3.82	6.06	9.80	7.33	1.58	−0.37	−0.31
Mauritius (MUS)	4.01	7.14	5.87	7.49	1.78	−0.23	−0.40
Mexico (MEX)	3.26	5.76	3.21	11.15	1.77	−0.27	−0.65
Morocco (MAR)	3.02	3.08	4.20	9.97	1.02	−0.06	−0.03
Thailand (THA)	4.13	4.31	5.50	7.10	1.04	−0.54	−0.38
Mean	4.21	6.33	9.84	13.40	1.48	−0.36	−0.28
Mean EMEs	3.48	5.68	5.99	13.19	1.67	−0.34	−0.36
Developed							
Australia (AUS)	1.66	1.40	1.26	8.54	0.84	−0.10	0.07
Austria (AUT)	1.57	2.08	2.30	11.72	1.32	0.00	−0.13
Canada (CAN)	2.19	2.24	1.94	4.97	1.02	0.03	−0.37
Sweden (SWE)	2.12	2.21	3.12	9.80	1.04	−0.03	−0.14
Switzerland (CHE)	2.21	1.89	3.60	11.40	0.86	−0.16	0.05
Mean	1.63	1.64	2.04	7.74	0.85	−0.04	−0.09

Notes: Data are annual and taken from the IFS. All series, except for the net exports to output ratio, are real per capita variables, have been logged and filtered using the HP filter with smoothing parameter $\lambda = 100$. Standard deviations are reported in percentage points. The samples are: Brazil, 1980–2010; Russia, 1995–2010; India, 1970–2010; China, 1986–2010; Colombia, 1970–2010; Indonesia, 1970–2010; Vietnam, 1995–2010; Egypt, 1982–2009; Turkey, 1987–2010; South Africa, 1960–2010; Argentina, 1970–2010; Chile, 1970–2009; Malaysia, 1970–2010; Mauritius, 1970–2010; Mexico, 1970–2010; Morocco, 1975–2008; Thailand, 1960–2010; Australia, 1960–2010; Austria, 1978–2010; Canada, 1950–2010; Sweden, 1950–2010; and Switzerland, 1970–2010.

Figure 3.1: Business Cycles in Output



Notes: Deviations of logged real GDP per capita from HP trend. Table notes of Table 3.1 on data information apply here, too.

instance, the degree of countercyclicality of the net exports to output ratio varies across EMEs. While Turkish GDP is highly negatively correlated with the net exports to output ratio, there is hardly any relation between these two variables in China. Similar discrepancies can be found regarding the excess volatility of consumption. In Mexico, the standard deviation of consumption is almost twice as high as the standard deviation of GDP. Conversely, there is virtually no excess volatility of consumption in Thailand and Morocco. Furthermore, although real depreciations are generally attended by higher net exports in EMEs, we do not observe this particular feature in Chile, China, and Morocco.

A large literature has been devoted to analysing these business cycle phenomena in emerging markets. Yet previous studies have predominantly focused on Latin American countries. Especially, Argentina (Kydland and Zarazaga (2002), Neumeyer and Perri (2005), and García-Cicco *et al.* (2010)) and Mexico (Aguiar and Gopinath (2007), Boz *et al.* (2011), and Chang and Férnandez (2013)) have been at the centre of earlier research. Given the potential heterogeneity across EMEs, we would like to contribute to the existing literature by investigating a broader selection of countries. In the empirical part of our paper in Sections 3.5 and 3.6, we therefore parametrise our DSGE model introduced below for the emerging markets of Mexico, South Africa, and Turkey as well as the advanced economies of Canada, Sweden, and Switzerland. This allows us to get more general insights into the different business cycle patterns in these two county groups.

3.2.2 Valuation Effects

Valuation effects refer to changes in a country's net foreign asset position that do not arise from cross–border financial flows but are due to movements in asset prices or exchange rates. Accordingly, valuation effects (VAL) are the difference between the change in the net foreign asset position (ΔNFA) and the current account (CA):

$$VAL = \Delta NFA - CA.$$

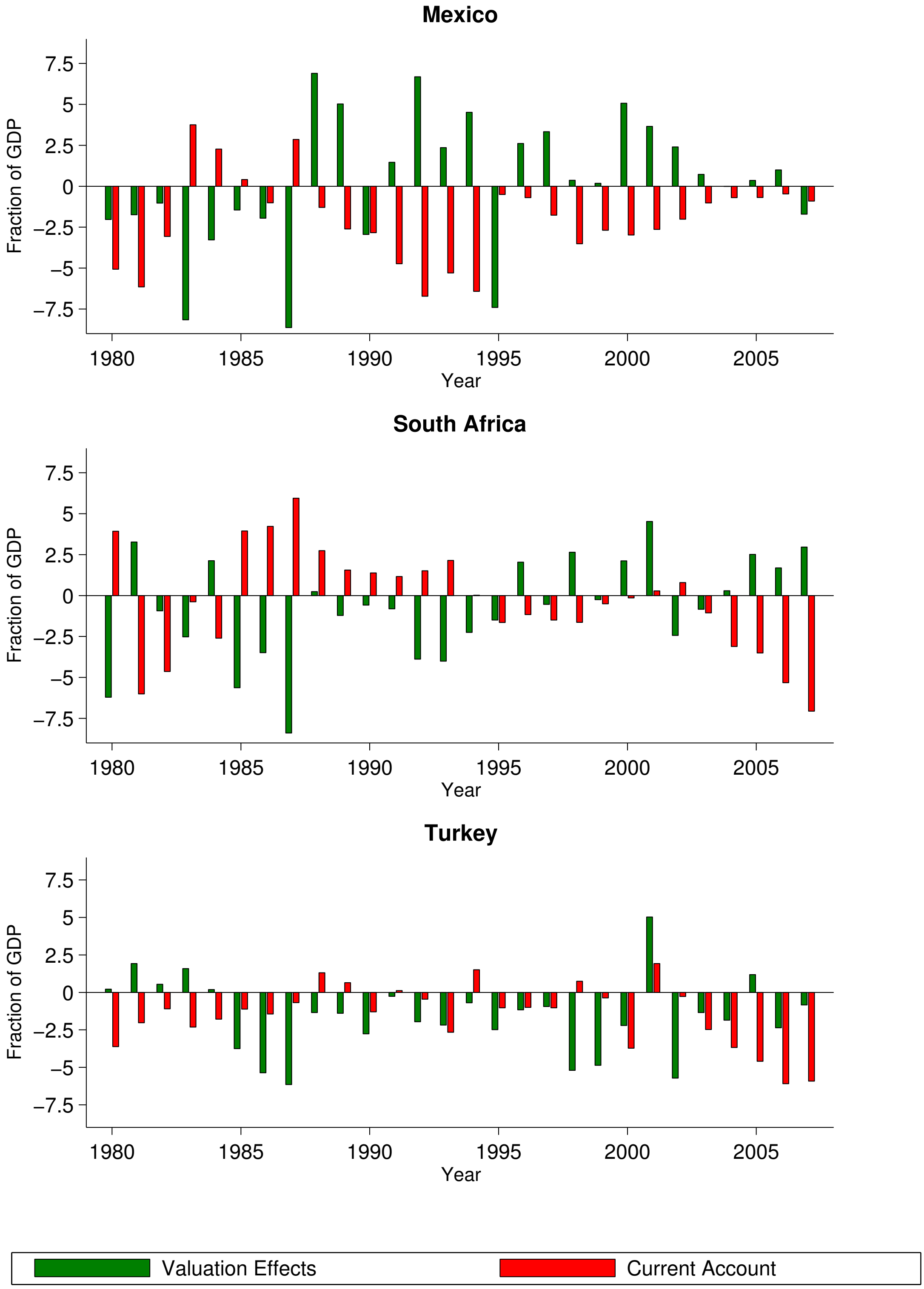
In this subsection, we investigate the relationship between valuation effects and the current account in EMEs. Our descriptive exercise relies on annual data on the stock of foreign liabilities in Mexico, South Africa, and Turkey over the time period from 1980 to 2007 provided by Lane and Milesi-Ferretti (2007). Current account data are taken from the IFS database. We use foreign debt instead of net foreign assets because it is the empirical counterpart to the net foreign asset position in the theoretical model analysed in this paper.[9] As a consequence, we calculate valuation effects simply by subtracting the current account from the negative change in the foreign debt position.[10]

Figure 3.2 portrays annual valuation effects as well as the current account, both as a percentage of current GDP. As is evident from the graph, there is a negative link between the current account and valuation effects. This is especially the case

[9]Note that foreign short–term debt traditionally accounts for a large part of the total external balance sheet in emerging markets (see Kose and Prasad (2010)). Consequently, movements in the net foreign asset position in these countries essentially reflect changes in foreign liabilities. It is therefore not surprising that we obtained similar results when we performed this exercise based on the actual net foreign asset position.

[10]Lane and Milesi-Ferretti (2007) point out that differences between the change in the net foreign asset position and the current account may also arise from other factors than valuation effects, such as measurement errors or omissions in the data. Therefore, we have to be careful when interpreting the magnitude of valuation effects computed here.

Figure 3.2: Valuation Effects and the Current Account in Emerging Markets



Notes: Valuation effects and the current account in Mexico, South Africa, and Turkey as a percentage of GDP. To compute valuation effects, we subtract the current account from the negative change in foreign liabilities. Data on foreign debt are taken from Lane and Milesi-Ferretti (2007), while current account data are retrieved from the IFS database.

for Mexico and South Africa but less obvious for Turkey. The sample correlation between the two series is −0.58, −0.75, and −0.05 for Mexico, South Africa, and Turkey, respectively. This means that a current account deficit is associated with positive valuation effects, which actually dampens the deterioration of the net foreign asset position. Hence, our descriptive analysis hints at a stabilising nature of valuation effects.

3.3 The Model

Consider a real business cycle model of a small open economy. The domestic economy is inhabited by a unit mass of atomistic, identical, and infinitely lived households. Agents form rational expectations and seek to maximise lifetime utility by consuming two differentiated commodities: a home–produced good as well as a foreign good imported from the rest of the world. Some key ingredients of our framework are borrowed from Aguiar and Gopinath (2007). In particular, production technology features both a permanent and a transitory stochastic component. In addition, we augment our setup with financial frictions as proposed by García-Cicco *et al.* (2010). That is, agents have access to an incomplete international credit market on which the price of debt is determined according to a debt–elastic interest rate rule.

In what follows, we choose the domestically produced good as numéraire and normalise its price in the home country to one, i.e. $p_{H,t} = 1$. Thus, all variables are expressed in units of the home good. Section 3.3.1 presents our *benchmark model*. In Section 3.3.2, we introduce a further financial distortion in our framework by assuming that domestic agents can only borrow in foreign currency on international capital markets. We call this modified setup the *liability dollarisation model*. Section 3.3.3 provides a summary of both models and shows how we solve them. A detailed description of the liability dollarisation model including the derivation of optimality and steady state conditions is presented in Appendix B.

3.3.1 Benchmark Model

Producing Economy

The home economy produces a differentiated domestic final good in a perfectly competitive environment. Technology is described by a neoclassical production function of the form

$$Y_t = z_t K_t^{\alpha} (\Gamma_t l_t)^{1-\alpha}, \tag{3.1}$$

with Y_t, l_t, K_t, and α denoting aggregate output of the home good, labour input, aggregate capital, and the economy's capital share, respectively. Moreover, z_t and Γ_t describe two different exogenous technology processes. On the one hand, the economy is exposed to transitory fluctuations in total factor productivity captured by z_t, which follows a stationary first–order autoregressive (AR) process in logs:

$$z_t = z_{t-1}^{\rho_z} \exp(\epsilon_t^z), \quad \text{with} \quad \epsilon_t^z \sim \mathcal{N}(0, \sigma_z^2). \tag{3.2}$$

On the other hand, we build on Aguiar and Gopinath (2007) and assume that the producing economy is not only hit by transitory shocks but also by trend shocks. For this reason, production technology features a non–stationary labour–augmenting productivity component represented by Γ_t, which equals the cumulative product of growth shocks:

$$\Gamma_t = g_t \Gamma_{t-1} = \prod_{s=0}^{t} g_s, \quad \text{where} \quad g_t = \mu_g^{1-\rho_g} g_{t-1}^{\rho_g} \exp(\epsilon_t^g), \quad \text{with} \quad \epsilon_t^g \sim \mathcal{N}(0, \sigma_g^2). \tag{3.3}$$

The underlying structure of the non–stationary technology process implies that a realisation of g_s will never die out and therefore has a permanent impact on Γ_t, for all $t \geq s$. Parameters $|\rho_z| < 1$ and $|\rho_g| < 1$ determine the persistence of the two exogenous processes. ϵ_t^z and ϵ_t^g represent shocks to the transitory and permanent technology process, respectively, with σ_z^2 and σ_g^2 being the corresponding variances. Finally, μ_g refers to the long–term or steady state gross growth rate of the economy.

Let I_t denote investment in the capital stock at date t. The evolution of the capital stock is described by the following law of motion:

$$K_{t+1} = (1-\delta)K_t + I_t - \frac{\phi}{2}\left(\frac{K_{t+1}}{K_t} - \mu_g\right)^2 K_t. \tag{3.4}$$

The last term in equation (3.4) introduces quadratic capital adjustment costs. Parameter ϕ determines the weight of adjustment costs and δ is the depreciation rate.

Representative Household

The representative household's objective is to maximise expected lifetime utility

$$\mathrm{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} u(C_t, 1-l_t), \tag{3.5}$$

where $\beta \in (0,1)$ is the subjective discount factor, $u(.)$ is period utility, which is assumed to be increasing and strictly concave in both arguments, and $(1-l_t)$ denotes time spent on leisure activities in period t. C_t is a composite consumption index characterised by a standard Dixit and Stiglitz (1977) Constant Elasticity of Substitution (CES) aggregate:

$$C_t = \left[\theta^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} + (1-\theta)^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}},$$

where $\theta \in (0,1)$ is the share of home goods in consumption, and $\eta \in (0,\infty)$ is the elasticity of intratemporal substitution between differentiated home and foreign goods. Consequently, $C_{H,t}$ and $C_{F,t}$ correspond to consumption of the home and foreign good, respectively.

We follow Aguiar and Gopinath (2007) and assume that preferences are described by a canonical Cobb–Douglas Constant Relative Risk Aversion (CRRA) utility function:[11]

$$u(C_t, 1 - l_t) = \frac{\left[C_t^{\gamma}(1 - l_t)^{1-\gamma}\right]^{1-\sigma}}{1 - \sigma},$$

where σ co–determines the degree of relative risk aversion, and $\gamma \in (0, 1)$ describes the consumption weight in utility.[12]

Our theoretical economy features only one non–contingent financial asset. At each time t, the representative agent can issue D_{t+1} one–period bonds on international capital markets at a predetermined risk–free rate r_t. Accordingly, the household faces the following period resource constraint:

$$Y_t + D_{t+1} \geq p_t C_t + I_t + D_t(1 + r_{t-1}), \tag{3.6}$$

where p_t denotes the price of composite consumption. Equation (3.6) embeds the standard interpretation. It simply requires that total expenditures at date t in form of consumption, investment, and debt repayments (RHS) are financed by income plus new loans (LHS).

Since variables Y_t, C_t, $C_{H,t}$, $C_{F,t}$, I_t, K_t, and D_t exhibit a stochastic trend, they need to be detrended in order to ensure stationarity of the system. Let lower case letters x_t indicate the stationary counterpart of X_t. We can then detrend our relevant variables in a straightforward manner:

$$x_t \equiv \frac{X_t}{\Gamma_{t-1}}.$$

We can now return to the optimisation rationale of the representative agent stated in (3.5). We can split the problem into two stages: *intratemporal* and *intertemporal* optimisation. First, *intratemporal* household optimisation yields the

[11] This instantaneous utility function is non–separable in consumption and leisure and thereby leads to income effects on labour supply. A number of studies in this strand of the literature (Mendoza (1991), Neumeyer and Perri (2005), García-Cicco *et al.* (2010), Boz *et al.* (2011), and Chang and Férnandez (2013)) use a quasi–linear period utility function pioneered by Greenwood *et al.* (1988), so–called GHH preferences, and generalised by Jaimovich and Rebelo (2009). A key characteristic of this preference specification is that it rules out any income effects on labour supply.

[12] Note that this functional form of utility implies that the Arrow–Pratt measure of relative risk aversion corresponds to $1 - \gamma(1 - \sigma)$ rather than σ. Accordingly, the elasticity of intertemporal substitution is given by $\frac{1}{1-\gamma(1-\sigma)}$.

following demand functions for the home and foreign consumption good:

$$c_{H,t} = \theta p_t^{\eta} c_t, \tag{3.7}$$

and

$$c_{F,t} = (1-\theta)\left(\frac{p_t}{p_{F,t}}\right)^{\eta} c_t. \tag{3.8}$$

In addition, the price index of composite consumption is determined by

$$p_t = \left[\theta + (1-\theta) p_{F,t}^{1-\eta}\right]^{\frac{1}{1-\eta}}, \tag{3.9}$$

where $p_{F,t}$ denotes the price of the foreign good expressed in units of the home–produced good.

Next, we consider the *intertemporal* optimisation problem. Final good producing firms are owned by the representative household who hires labour and rents capital for which it pays competitive prices. Thus, we can combine the detrended versions of the production function (3.1), the law of motion of capital (3.4), and the aggregate resource constraint (3.6) to state the stationary maximisation problem at time t as

$$\max_{\{c_\tau, l_\tau, k_{\tau+1}, d_{\tau+1}\}} \mathrm{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} (\Gamma_{\tau-1}^{\gamma(1-\sigma)} u(c_\tau, 1-l_\tau))$$

s.t.

$$y_\tau + (1-\delta)k_\tau + g_\tau d_{\tau+1} \geq p_\tau c_\tau + g_\tau k_{\tau+1} + \frac{\phi}{2}\left(g_\tau \frac{k_{\tau+1}}{k_\tau} - \mu_g\right)^2 k_\tau + d_\tau(1+r_{\tau-1}),$$

taking as given k_t, d_t, as well as the transversality condition $\lim_{j\to\infty} \mathrm{E}_t \left[\prod_{s=0}^{j-2} \frac{d_{t+j}}{1+r_{t+s}}\right] = 0$. The solution to this maximisation problem renders the following optimality conditions:

$$\frac{1}{c_t}\left(c_t^{\gamma}(1-l_t)^{1-\gamma}\right)^{1-\sigma} = g_t^{\gamma(1-\sigma)-1} \beta \mathrm{E}_t \Bigg[\frac{1}{c_{t+1}}\left(c_{t+1}^{\gamma}(1-l_{t+1})^{1-\gamma}\right)^{1-\sigma} \cdot \frac{p_t\left(\alpha \frac{y_{t+1}}{k_{t+1}} + (1-\delta) + \phi\left(g_{t+1}\frac{k_{t+2}}{k_{t+1}} - \mu_g\right) g_{t+1}\frac{k_{t+2}}{k_{t+1}} - \frac{\phi}{2}\left(g_{t+1}\frac{k_{t+2}}{k_{t+1}} - \mu_g\right)^2\right)}{p_{t+1}\left(1 + \phi\left(g_t \frac{k_{t+1}}{k_t} - \mu_g\right)\right)}\Bigg], \tag{3.10}$$

$$\frac{1}{c_t}\left(c_t^{\gamma}(1-l_t)^{1-\gamma}\right)^{1-\sigma} = \beta g_t^{\gamma(1-\sigma)-1}\mathrm{E}_t\left[\frac{1}{c_{t+1}}\left(c_{t+1}^{\gamma}(1-l_{t+1})^{1-\gamma}\right)^{1-\sigma}\frac{p_t}{p_{t+1}}\right](1+r_t), \qquad (3.11)$$

and

$$p_t\frac{1-\gamma}{\gamma}\frac{c_t}{1-l_t} = (1-\alpha)\frac{y_t}{l_t}. \qquad (3.12)$$

Equations (3.10) and (3.11) represent the intertemporal Euler equations with respect to capital and bond holdings, respectively. Condition (3.12) specifies the standard labour–leisure trade–off.

Interest Rates

We assume that the interest rate r_t on international debt borrowed at date t and due in period $t+1$ is increasing in expected future external debt relative to income:

$$r_t = r + \psi\left(\exp\left(\mathrm{E}_t\left[\frac{D_{t+1}}{Y_{t+1}}\right] - \frac{D}{Y}\right) - 1\right). \qquad (3.13)$$

The reason why we introduce this interest rate rule in our setup is twofold. First, as Schmitt-Grohé and Uribe (2003) point out, it is a convenient way to make the deterministic equilibrium independent of initial conditions and thus to close the model. Second, it allows us to feature financial frictions in our theoretical economy in a reduced form.

According to equation (3.13), the cost of debt depends on the steady state interest rate r, the economy's steady state debt to GDP ratio $\frac{D}{Y}$, and the expected level of debt over GDP in the next period $\mathrm{E}_t\left[\frac{D_{t+1}}{Y_{t+1}}\right]$. Note that for ease of interpretation we use the debt to GDP ratio to determine the interest rate rather than the level of total debt. Intuitively, a country finds it hard to borrow on soft terms and is charged a premium over the equilibrium interest rate if it is expected to face high debt relative to the size of its economy in the future.[13]

[13]Admittedly, there is no micro foundation upon which we build our interest rate rule. Nevertheless, the imposed positive relationship between debt over GDP and borrowing costs in our framework is consistent with findings in the sovereign debt literature. For instance, Arellano (2008) develops a model which shows how higher indebtedness increases the probability of default and thus raises the interest rate. Likewise, a large body of empirical research has emphasised the importance of a country's external debt in explaining interest rate spreads (see Uribe and Yue (2006)). Furthermore, as Uribe (2006) demonstrates, we could also introduce a borrowing constraint in our small open economy framework to generate an endogenous country spread. In such a model, a premium over the equilibrium interest rate emerges if the debt ceiling is binding. In light of this, we believe that our interest rate rule provides a convenient way to capture credit

In our benchmark setup, we follow García-Cicco *et al.* (2010) and interpret ψ as a catchall parameter for financial frictions and financial development. A high value of ψ implies that the interest rate reacts more sensitively to changes in the expected future debt to GDP ratio, which reflects severe capital market distortions in the economy.[14] García-Cicco *et al.* (2010) highlight the importance of the size of ψ for the analysis of business cycles in both developed economies and EMEs. In light of this, our empirical analysis below permits ψ to take on values that are substantially greater than zero. Therefore, we allow for variation in the interest rate, which entails important implications for the dynamics in our model.[15]

Exchange Rate

The household's optimisation problem abroad is analogous to the home country. Since we consider an SOE framework, the home economy is infinitesimally small relative to the rest of the world. That is, the foreign country is approximately closed and only consumes goods produced abroad. As a result, the foreign price index of the foreign consumption composite $p_t^\star$ boils down to the foreign price of goods produced in the rest of the world $p_{F,t}^\star$, i.e. $p_t^\star = p_{F,t}^\star$. We assume that the law of one price holds, such that

$$p_{F,t} = \frac{p_{F,t}^\star}{s_t} = \frac{p_t^\star}{s_t},$$

where $s_t = p_{H,t}^\star$ defines the price of the home good in the foreign country. In fact, s_t can be interpreted as the "nominal exchange rate" determining the price of the domestic currency in terms of the foreign currency, since we have normalised the

market imperfections even though it leaves out an endogenous explanation within the model.

[14]At this point it is intuitive to look at the log–linearised version of the interest rate rule given by

$$\widehat{r_t}\, r = \frac{d}{y}\psi \mathrm{E}_t\left[\widehat{d_{t+1}} - \widehat{y_{t+1}}\right] \qquad \Leftrightarrow \qquad \frac{\Delta r_t}{\Delta \mathrm{E}_t\left[\left(\frac{d}{y}\right)_{t+1}\right]} \approx \psi,$$

where hatted variables denote log–deviations from steady state and Δ indicates absolute changes. Accordingly, $\widehat{r_t} \cdot r$ approximately corresponds to the absolute deviation of the interest rate from its steady state value r. Hence, we can identify the effective debt–elasticity of the interest rate as $\frac{\psi}{r} \cdot \frac{d}{y}$. More specifically, parameter ψ determines by how many percentage points the interest rate at date t increases if, *ceteris paribus*, we expect the debt to income ratio to rise by one percentage point in period $t+1$.

[15]ψ needs to be positive in order to induce stationarity. However, Aguiar and Gopinath (2007) and other related studies set ψ equal to 0.001, i.e. virtually equal to zero. In doing so, these authors basically shut down interest rate changes and thereby eliminate any feedback effects from the interest rate on other macroeconomic variables (see García-Cicco *et al.* (2010)).

domestic price of the home good to one ($p_{H,t} = 1$). As a result, we can define the real exchange rate as the price of the domestic composite consumption good in units of the foreign composite consumption good:

$$e_t = \frac{p_t s_t}{p_t^\star} = \frac{p_t s_t}{p_{F,t}^\star} = \frac{p_t s_t}{p_{F,t} s_t} = \frac{p_t}{p_{F,t}}. \tag{3.14}$$

Net Exports and Current Account

We assume that the consumption index of agents abroad is also characterised by a CES aggregate. For simplicity, we also assume that variables in the domestic economy and the rest of the world exhibit the same stochastic trend component, i.e. $\Gamma_{t-1} = \Gamma_{t-1}^\star$. Let $c_t^\star$ denote detrended foreign consumption, such that we can derive foreign demand for the home good, from the perspective of the home country, as

$$c_{H,t}^\star = \theta^\star p_{F,t}^{\eta^\star} c_t^\star, \tag{3.15}$$

where $\theta^\star \in (0, 1)$ denotes the share of home goods in foreign consumption, and $\eta^\star \in (0, \infty)$ is the elasticity of intratemporal substitution abroad.

Consequently, net exports in the home economy can be easily calculated as the difference between exports and imports:

$$nx_t = c_{H,t}^\star - p_{F,t} c_{F,t}. \tag{3.16}$$

Furthermore, the current account is given by the trade balance minus interest payments on external debt:

$$ca_t = -r_{t-1} d_t + nx_t. \tag{3.17}$$

As in any standard intertemporal model of the current account (see Obstfeld and Rogoff (1996)), the current account in our benchmark economy simply equals the change in the country's net foreign asset position:

$$\Delta nfa_{t+1} = -g_t d_{t+1} + d_t = ca_t. \tag{3.18}$$

General Equilibrium

In a general equilibrium, all markets have to clear. Equilibrium in the market for the home–produced good requires that output equals domestic absorption plus foreign demand:

$$y_t = c_{H,t} + i_t + c^{\star}_{H,t}. \tag{3.19}$$

Finally, foreign consumption is assumed to follow an exogenous first–order AR process in logs:

$$c^{\star}_t = (c^{\star}_{t-1})^{\rho_c} \exp(\epsilon^c_t), \quad \text{with} \quad \epsilon^c_t \sim \mathcal{N}(0, \sigma^2_c). \tag{3.20}$$

This specification introduces external disturbances in our setup, which potentially allows foreign demand shocks, along with permanent and transitory productivity shocks, to drive the dynamics in the model.

3.3.2 Liability Dollarisation

A well–known characteristic of EMEs is that they have had difficulties in borrowing in their own currencies on international capital markets.[16] In fact, the bulk of external debt in these countries has traditionally been issued in major currencies like US dollar, euro, sterling, or Swiss francs (see Eichengreen *et al.* (2005)). Being denominated in foreign currency, the amount of outstanding loans is subject to substantial exchange rate fluctuations which may induce non–negligible external balance sheet effects. In order to account for this phenomenon, which is often referred to as liability dollarisation, we now extend our benchmark framework from the previous subsection along this dimension.

The basic structure of the model coincides with our benchmark model. Thus, most of equations and optimality conditions from Section 3.3.1 simply carry over. As we have set up our model in real terms, liability dollarisation means that the home country can only borrow in units of foreign consumption. Accordingly, the

[16]This phenomena has been documented by an extensive literature. See, for instance, Reinhart *et al.* (2003b), Lane and Shambaugh (2010), and contributions in Eichengreen and Hausmann (2005).

resource constraint of the economy adjusts to[17]

$$Y_t + p_t \frac{D_{t+1}}{e_t} \geq p_t C_t + I_t + p_t \frac{D_t}{e_t}(1 + r_{t-1}). \tag{3.21}$$

This has an immediate impact on household optimisation, such that we obtain an intertemporal Euler equation with respect to foreign debt of

$$\frac{1}{c_t}\left(c_t^{\gamma}(1-l_t)^{1-\gamma}\right)^{1-\sigma} = \beta g_t^{\gamma(1-\sigma)-1} \mathrm{E}_t\left[\frac{1}{c_{t+1}}\left(c_{t+1}^{\gamma}(1-l_{t+1})^{1-\gamma}\right)^{1-\sigma}\frac{e_t}{e_{t+1}}\right](1+r_t). \tag{3.22}$$

Note that liability dollarisation changes the price of consumption at date t expressed in units of date $t+1$ relative to the benchmark case in equation (3.11). In particular, it alters the impact of the exchange rate fluctuations on the optimal intertemporal consumption allocation of the representative household.

In addition, our interest rate rule modifies to

$$r_t = r + \psi\left(\exp\left(\mathrm{E}_t\left[\frac{p_{t+1}D_{t+1}}{e_{t+1}Y_{t+1}}\right] - \frac{pD}{eY}\right) - 1\right). \tag{3.23}$$

It is worth emphasising that with interest rates determined by equation (3.23), parameter ψ can no longer be interpreted as a catchall variable for financial frictions as we do in the benchmark economy (see equation (3.13)). When households issue new debt, they do not know how much they have to repay in the future because exchange rate variations change the value of outstanding debt. Hence, the fact that countries are forced to borrow in foreign currency itself represents a special form of capital market distortions. In the model at hand we can therefore encompass the extent of financial frictions by the interplay of liability dollarisation and debt–elastic interest rates.[18]

Importantly, the value of outstanding international debt depends on the evol-

[17]Note that international debt D is expressed in units of the foreign composite consumption good such that $\frac{D}{e}$ is denoted in units of the domestic consumption good. Hence, we have to multiply $\frac{D}{e}$ by the price of domestic consumption p in order to obtain foreign debt expressed in units of the home–produced good.

[18]Note that the log–linearised version of the interest rate rule is given by

$$\widehat{r_t}\, r = \frac{pd}{ey}\psi \mathrm{E}_t\left[\widehat{p_{t+1}} + \widehat{d_{t+1}} - \widehat{y_{t+1}} - \widehat{e_{t+1}}\right] \qquad \Leftrightarrow \qquad \frac{\Delta r_t}{\Delta \mathrm{E}_t\left[\left(\frac{pd}{ey}\right)_{t+1}\right]} \approx \psi.$$

The interpretation of the size of parameter ψ is the same as in the benchmark case.

ution of the real exchange rate. As a result, the change in the country's net foreign asset position no longer equals the current account but is now adjusted for valuation effects stemming from exchange rate changes. We can write the detrended current account as

$$ca_t = nx_t - r_{t-1} p_t \frac{d_t}{e_t}. \tag{3.24}$$

Moreover, we derive the change in detrended net foreign assets as the sum of the current account and valuation effects:

$$\begin{aligned}
& \Delta nfa_t = -g_t p_t \frac{d_{t+1}}{e_t} + p_{t-1} \frac{d_t}{e_{t-1}} && (3.25)\\
\overset{(3.21)}{\Longleftrightarrow} \quad & \Delta nfa_t = y_t - p_t c_t - i_t - r_{t-1} p_t \frac{d_t}{e_t} + p_{t-1} \frac{d_t}{e_{t-1}} - p_t \frac{d_t}{e_t} \\
\overset{(3.19)}{\Longleftrightarrow} \quad & \Delta nfa_t = c^{\star}_{H,t} - p_{F,t} c_{F,t} - r_{t-1} p_t \frac{d_t}{e_t} + d_t \left(\frac{p_{t-1}}{e_{t-1}} - \frac{p_t}{e_t} \right) \\
\overset{(3.16)}{\Longleftrightarrow} \quad & \Delta nfa_t = nx_t - r_{t-1} p_t \frac{d_t}{e_t} + d_t \left(\frac{p_{t-1}}{e_{t-1}} - \frac{p_t}{e_t} \right) \\
\overset{(3.24)}{\Longleftrightarrow} \quad & \Delta nfa_t = ca_t + val_t.
\end{aligned}$$

Hence, the stationary version of valuation effects at date t is given by

$$val_t = d_t \left(\frac{p_{t-1}}{e_{t-1}} - \frac{p_t}{e_t} \right). \tag{3.26}$$

3.3.3 Model Solution

Once the variables incorporating the stochastic permanent component have been detrended, the models introduced above constitute stationary systems of non–linear expectational difference equations. In the benchmark model the system is featured by 18 variables (y_t, c_t, r_t, e_t, i_t, l_t, $c_{H,t}$, $c_{F,t}$, $c^{\star}_{H,t}$, p_t, $p_{F,t}$, nx_t, ca_t, k_t, d_t, z_t, g_t, $c^{\star}_t$) in the stationary versions of equations (3.1), (3.2), (3.3), (3.4), (3.6), (3.7), (3.8), (3.9), (3.10), (3.11), (3.12), (3.13), (3.14), (3.15), (3.16), (3.17), (3.19), and (3.20). The model with liability dollarisation forms a system of 20 variables (y_t, c_t, r_t, e_t, i_t, l_t, $c_{H,t}$, $c_{F,t}$, $c^{\star}_{H,t}$, p_t, $p_{F,t}$, nx_t, ca_t, Δnfa_t, val_t, k_t, d_t, z_t, g_t, $c^{\star}_t$) in the detrended versions of equations (3.1), (3.2), (3.3), (3.4), (3.7), (3.8), (3.9), (3.10), (3.12), (3.14), (3.15), (3.16), (3.19), (3.20), (3.21), (3.22), (3.23), (3.24), (3.25), and (3.26).

For each setup, we use a first–order approximation of the respective model solution and log–linearise the system around its deterministic steady state. All equations being log–linearised, we end up with a linear system of first–order expectational difference equations, which we solve using the method proposed by Klein (2000). The solution yields a state space representation of the form

$$\begin{aligned} \mathbf{y}_t &= \mathbf{Z}\boldsymbol{\alpha}_t \\ \boldsymbol{\alpha}_t &= \mathbf{T}\boldsymbol{\alpha}_{t-1} + \mathbf{R}\boldsymbol{\eta}_t, \end{aligned} \tag{3.27}$$

where $\mathbf{y_t}$ is an $(n \times 1)$ vector of control variables and $\boldsymbol{\alpha}_t$ is the $(m \times 1)$ unobservable state vector, which is driven by the exogenous processes $\boldsymbol{\eta}_t$ of dimension $(x \times 1)$. Therefore, the matrix $\mathbf{R}$, which links the state variables to the exogenous processes, has dimension $(m \times x)$.[19] This representation enables us to estimate certain structural parameters of our models using country–specific data, which will be described in detail in the next section.

3.4 Estimation and Calibration

To gauge the models' ability to explain macroeconomic dynamics in EMEs, we quantify our theoretical economy for three EMEs: Mexico, South Africa, and Turkey. Furthermore, to assess the peculiarity of business cycles in emerging markets, we also parametrise the benchmark model for a group of developed small open economies, represented by Canada, Sweden, and Switzerland.

We choose a mixture of country–specific calibration and Bayesian estimation. In particular, we estimate the parameters determining the exogenous processes in the model as well as the debt–elasticity of the interest rate ψ. All other parameters are calibrated. Given our focus on the role of liability dollarisation as a form of financial frictions in EMEs, we estimate both models for Mexico, South Africa, and Turkey, whereas for our developed economies, we only analyse the benchmark framework.

[19]Accordingly, in the benchmark model, we have $x = 3$, $m = 5$, and $n = 13$. In the liability dollarisation model, we have $x = 3$, $m = 5$, and $n = 15$.

3.4.1 Data

The time unit t in our theoretical economy is counted as quarters. To estimate our linearised models, we use quarterly time series on real per capita GDP and consumption, real interest rates, and real exchange rates. All data are taken from the IFS database. The time series of real per capita output and consumption are seasonally adjusted using the Census Bureau's X–12 ARIMA procedure. Our selection of countries and sample period is motivated by data availability and comparability with existing literature. Table 3.2 summarises the sample period used for estimation for each country.

Table 3.2: Data for Estimation

Emerging Markets		Developed Economies	
Mexico (MEX)	1981Q1–2011Q4	Canada (CAN)	1960Q1–2011Q4
South Africa (ZAF)	1960Q1–2011Q4	Sweden (SWE)	1981Q1–2011Q4
Turkey (TUR)	1987Q1–2011Q4	Switzerland (CHE)	1970Q1–2011Q3

Notes: All data are taken from the IFS database. Variables used for estimation are real GDP per capita, real consumption per capita, the real interest rate, and the real exchange rate.

To calculate real per capita variables, we divide the respective nominal series by population and subsequently deflate output using the GDP deflator and consumption using the CPI. Population data are only available on an annual frequency. Hence, we pin down population in the respective second quarter at the reported annual figure and interpolate missing data points using annual growth rates. Our construction of real interest rates is similar to the approach chosen by Neumeyer and Perri (2005). That is, we subtract domestic expected inflation based on the GDP deflator from the annual nominal interest rate, which is then transformed into a 3–month rate.[20] Expected inflation is calculated as the average of actual inflation in the current period and the three previous quarters. Finally, for each country we construct a real exchange rate index, which is normalised to 100 in 2005Q2 by multiplying the respective nominal US dollar exchange rate

[20]For Canada, Mexico, South Africa, Sweden, and Switzerland we use T–bill rates, whereas for Turkey we take the deposit rate. Note that Neumeyer and Perri (2005) subtract expected US inflation from the dollar interest rate based on the J.P. Morgan Emerging Market Bond Index (EMBI) spread. We use domestic expected inflation instead because our model describes the behaviour of a domestic representative agent as opposed to an international investor.

(US dollar per national currency) by the domestic CPI and dividing by the US CPI. Moreover, we follow García-Cicco *et al.* (2010) and filter our data prior to estimation by removing the cubic trend from the real series in logs.

3.4.2 Calibration

Table 3.3 reports the calibration of our parameters. We keep the majority of structural parameters constant across both models and countries, and assign conventional values suggested by previous literature. In doing so, we try to retain a high degree of comparability with earlier contributions. In particular, we follow Aguiar and Gopinath (2007) and set the subjective discount factor β equal to 0.98, the weight of consumption in the utility function γ equal to 0.36, the parameter governing the curvature of the utility function σ equal to 2, the weight of the adjustment costs ϕ equal to 4, the capital share in the production function equal to 0.32, and the rate of depreciation δ equal to 0.05. Without loss of generality, we normalise the mean value of both the transitory productivity process z and the foreign consumption process $c^\star$ to 1. There is no consensus in the literature concerning which value to choose for the elasticity of intratemporal substitution between home and foreign goods (see Obstfeld and Rogoff (2000)). We assume that the price elasticity of goods is the same throughout the world and follow Corsetti and Pesenti (2001) by setting its value equal to unity, i.e. $\eta = \eta^\star = 1$. Moreover, we pin down $\theta = 0.8$ and $\theta^\star = 0.2$ to match a consumption import share both at home and abroad of 20 percent. This choice is motivated by empirical figures reported in Burstein *et al.* (2005).

Two parameters are fixed country–specifically. We calibrate the mean of the non–stationary productivity process μ_g at the average quarterly gross growth rate of real per capita GDP. We pin down the steady state external debt to GDP ratio at the average annual net foreign asset position.[21] That is, we set $\frac{D}{Y}$ in the benchmark model and $\frac{pD}{eY}$ in the model with liability dollarisation equal to 35.63 percent, 24.36 percent, 23.20 percent, 31.08 percent, and 18.63 percent for Mexico, South Africa, Turkey, Canada, and Sweden, respectively. Switzerland is a net creditor to the

[21] Average net foreign asset positions are calculated based on annual data between 1970 and 2007 collected by Lane and Milesi-Ferretti (2007).

Table 3.3: Calibrated Values

		General Parameters			
β	discount factor	0.98	$\theta^\star$	foreign share of home goods	0.20
γ	consumption weight in utility	0.36	η	domestic elasticity of intratemporal substitution	1.00
σ	curvature of utility	2.00			
ϕ	weight of adjustment costs	4.00	$\eta^\star$	foreign elasticity of intratemporal substitution	1.00
α	capital share	0.32			
δ	depreciation rate	0.05	z	mean of z process	1.00
θ	domestic share of home goods	0.80	$c^\star$	mean of $c^\star$ process	1.00
		Country–specific Parameters			
$\left(\frac{p}{e}\cdot\right)\frac{D}{Y}$	external debt ratio		μ_g	mean gross growth rate	
	MEX	0.36		MEX	1.0018
	ZAF	0.24		ZAF	1.0026
	TUR	0.23		TUR	1.0063
	CAN	0.31		CAN	1.0049
	SWE	0.19		SWE	1.0046
	CHE	−0.90		CHE	1.0029

Notes: In the benchmark model, we pin down $\frac{D}{Y}$. In the model with liability dollarisation, we calibrate $\frac{pD}{eY}$ at the reported value of the external debt to income ratio.

rest of the world and thus exhibits a positive average net foreign asset position relative to GDP of 90 percent.

3.4.3 Estimation

Similar to recent studies in this field of research (e.g. García-Cicco *et al.* (2010) and Chang and Férnandez (2013)), we adopt a Bayesian viewpoint. Besides computational advantages, this allows us to incorporate prior beliefs about the structural parameters in a straightforward manner. As pointed out above, the size of parameter ψ, which determines the debt–elasticity of interest rates, may have important implications for the dynamics in the model. However, ex–ante we do not have strong beliefs about the size of the debt–elasticity of interest rates. To this end, we estimate parameter ψ as well as the parameters governing the exogenous structural shocks in the model.

A major contribution of this work is that our estimation procedure allows for a dynamic structure in the "measurement error", which captures the off–model dynamics in the data. To our knowledge, this represents a novel approach in this strand of the literature. Related previous studies deal differently with the crucial issue on how to address these residual dynamics of our observable variables in the estimation.[22] Naturally, our SOE setup is too stylised to account for all the dynamics in real macroeconomic time series. Hence, we build on Sargent (1989) and Ireland (2004) and include a (vector–)autoregressive "measurement error" component to capture the dynamics in the data that cannot be replicated by the structural model itself. Accordingly, our state space representation in equation (3.27) modifies to

$$\begin{aligned} \mathbf{y}_t &= \mathbf{Z}\boldsymbol{\alpha}_t + \boldsymbol{\epsilon}_t \\ \boldsymbol{\alpha}_t &= \mathbf{T}\boldsymbol{\alpha}_{t-1} + \mathbf{R}\boldsymbol{\eta}_t, \qquad \boldsymbol{\eta}_t \sim \mathcal{N}(\mathbf{0}, \boldsymbol{\Sigma}) \\ \boldsymbol{\epsilon}_t &= \mathbf{A}\boldsymbol{\epsilon}_{t-1} + \boldsymbol{\xi}_t, \qquad \boldsymbol{\xi}_t \sim \mathcal{N}(\mathbf{0}, \boldsymbol{\Omega}) \end{aligned} \tag{3.28}$$

where $\boldsymbol{\epsilon}_t$ is an $(n_{estimation} \times 1)$ vector of measurement errors and $n_{estimation}$ denotes the number of observables we use for estimation, which is four in our case. We assume that the off–model dynamics inherent in each variable follow an autoregressive process, such that all off–diagonal entries of the $(n_{estimation} \times n_{estimation})$ coefficient matrix $\mathbf{A}$ are restricted to zero.

We apply a Markov Chain Monte Carlo (MCMC) simulation by using the Metropolis–Hastings algorithm within the Gibbs sampler to derive the posterior distributions of the parameters. First, we implement Gibbs sampling to simulate the posteriors of the parameters defining our exogenous processes ρ_z, σ_z^2, ρ_g, σ_g^2, ρ_c, σ_c^2, $\mathbf{A}$, and $\boldsymbol{\Omega}$. Then, at each simulation iteration, conditional on the current Gibbs draw, we add a Metropolis–Hastings step in order to approximate the posterior distribution of ψ. We therefore apply a random walk Metropolis Hastings algorithm in which we choose the variance of the proposal density, such that we get an acceptance ratio of about 20 to 40 percent. We estimate the whole model with different starting values in order to control for the possibility of multiple modes in the posterior distribution.

Apart from the volatility in the off–model dynamics, our prior beliefs are constant across all models and countries. They are summarised in Table 3.4. We impose a normal distribution with mean 0.5 and variance 0.02 on the autore-

[22] For instance, García-Cicco *et al.* (2010) and Chang and Férnandez (2013) impose a simple White Noise process on the measurement error. In addition, García-Cicco *et al.* (2010) tightly restrict the variance of the measurement error, so that it cannot explain more than 6 percent of the variation in the respective observable variable.

Table 3.4: Prior Distributions

	Prior Dist.	Prior 90% Bands	Prior Dist.	Prior 90% Bands	Prior Dist.	Prior 90% Bands
			Harmonised Priors			
ψ			$\mathcal{U}(0.001, 5)$	–		
ρ_z			$\mathcal{N}(0.5, 0.02)$	[0.269,0.733]		
ρ_g			$\mathcal{N}(0.5, 0.02)$	[0.269,0.733]		
ρ_c			$\mathcal{N}(0.5, 0.02)$	[0.269,0.733]		
ρ_{ϵ_y}			$\mathcal{N}(0, 0.05)$	[−0.367,0.367]		
ρ_{ϵ_c}			$\mathcal{N}(0, 0.05)$	[−0.367,0.367]		
ρ_{ϵ_r}			$\mathcal{N}(0, 0.05)$	[−0.367,0.367]		
ρ_{ϵ_e}			$\mathcal{N}(0, 0.05)$	[−0.367,0.367]		
σ_z^2			$\mathcal{IG}(2.05, 0.011)$	[0.002,0.028]		
σ_g^2			$\mathcal{IG}(2.05, 0.011)$	[0.002,0.028]		
σ_c^2			$\mathcal{IG}(2.05, 0.011)$	[0.002,0.028]		
			Country–Specific Priors			
	Mexico		**South Africa**		**Turkey**	
$\sigma_{\epsilon_y}^2$	$\mathcal{IG}(2.00, 0.001)$	[0.000,0.002]	$\mathcal{IG}(2.00, 0.001)$	[0.000,0.002]	$\mathcal{IG}(2.00, 0.002)$	[0.000,0.006]
$\sigma_{\epsilon_c}^2$	$\mathcal{IG}(2.01, 0.003)$	[0.001,0.010]	$\mathcal{IG}(2.00, 0.002)$	[0.000,0.006]	$\mathcal{IG}(2.01, 0.004)$	[0.001,0.012]
$\sigma_{\epsilon_r}^2$	$\mathcal{IG}(2.00, 0.001)$	[0.000,0.002]	$\mathcal{IG}(2.00, 0.000)$	[0.000,0.000]	$\mathcal{IG}(2.00, 0.000)$	[0.000,0.001]
$\sigma_{\epsilon_e}^2$	$\mathcal{IG}(2.16, 0.021)$	[0.004,0.050]	$\mathcal{IG}(2.21, 0.025)$	[0.005,0.056]	$\mathcal{IG}(2.15, 0.020)$	[0.004,0.050]
	Canada		**Sweden**		**Switzerland**	
$\sigma_{\epsilon_y}^2$	$\mathcal{IG}(2.00, 0.001)$	[0.000,0.003]	$\mathcal{IG}(2.00, 0.001)$	[0.000,0.004]	$\mathcal{IG}(2.00, 0.001)$	[0.000,0.001]
$\sigma_{\epsilon_c}^2$	$\mathcal{IG}(2.00, 0.001)$	[0.000,0.002]	$\mathcal{IG}(2.00, 0.001)$	[0.000,0.003]	$\mathcal{IG}(2.00, 0.001)$	[0.000,0.001]
$\sigma_{\epsilon_r}^2$	$\mathcal{IG}(2.00, 0.000)$	[0.000,0.000]	$\mathcal{IG}(2.00, 0.000)$	[0.000,0.000]	$\mathcal{IG}(2.00, 0.000)$	[0.000,0.000]
$\sigma_{\epsilon_e}^2$	$\mathcal{IG}(2.02, 0.007)$	[0.001,0.019]	$\mathcal{IG}(2.00, 0.022)$	[0.005,0.062]	$\mathcal{IG}(2.24, 0.028)$	[0.005,0.060]

gressive coefficients of structural shocks. Regarding the persistence parameters of measurement errors, it is more difficult to come up with informative priors. Therefore, we implement rather diffuse priors and assume they follow a normal distribution with zero mean and variance 0.05. Since the normal distribution has infinite support, we enforce stationarity by restricting the AR coefficients to lie within the unit circle. Priors on the volatility of the structural exogenous processes are harmonised and are described by an inverse Gamma distribution with shape parameter 2.05 and scale factor 0.0105.[23] Furthermore, we fix the prior distribution of the measurement error variance country–specifically, such that its mean matches the variance of the respective observable time series used for estimation. Finally, we impose a fairly flat uniform distribution with support $[0.001, 5]$ on our financial frictions parameter ψ.

[23] This prior distribution implies a mean of 0.01 and variance of 0.002.

3.5 Estimation Results

This section discusses the estimation results for the six countries under investigation. First, we present the posterior distributions of our estimated parameters. Then, we run a "horse race" between the benchmark model and the liability dollarisation setup with respect to their ability to capture the dynamics in our four observable variables.

3.5.1 Parameter Distributions

In the following, we focus on the estimation results concerning the structural part of the model. Table 3.5 displays the posterior distribution of the estimated structural parameters. A complete description of all estimated parameters, including those determining the off–model dynamics, can be found in Appendix B.

All results are based on 150,000 draws of which the initial 100,000 (125,000) draws were burned for EMEs (developed economies). We keep only every 25$^{\text{th}}$ (10$^{\text{th}}$) draw for EMEs (developed economies) in order to avoid autocorrelation problems. Furthermore, we have performed a convergence test for each specification. Columns four and seven in Table 3.5 report the p–values of Geweke's χ^2–test (see Geweke (1992)). We can never reject the null of convergence at conventional significance levels. Therefore, we are rather confident that our posterior distributions have converged.

Let us first consider the estimates of parameter ψ. We do not only find heterogeneity with respect to the choice of the model but also regarding the country group. What is striking is that ψ is considerably higher in the benchmark economy than in the model featuring foreign currency debt. Thus, once we introduce liability dollarisation as a further form of capital market imperfections, the estimated debt–elasticity of interest rates becomes less pronounced.[24] This is particularly the case for the Mexican economy, where we observe an extreme discrepancy in ψ

[24]Admittedly, this finding is not very surprising. In the liability dollarisation setup, variation in the interest rate can additionally be attributed to exchange rates fluctuations. Compare the interest rate rules in equations (3.13) and (3.23). Since real exchange rates in EMEs tend to be procyclical, volatility on the right–hand side of the interest rate rule unambiguously rises once we introduce liability dollarisation, while it remains unchanged on the left–hand side, such that factor ψ must decline.

Table 3.5: Posterior Distributions of Structural Parameters

	Posterior Median	Posterior 90% Bands	χ^2 Test	Posterior Median	Posterior 90% Bands	χ^2 Test
			EMERGING MARKET ECONOMIES			
			MEXICO			
		BENCHMARK			**LIABILITY DOLLARISATION**	
ψ	4.342	[3.315,4.885]	0.27	0.216	[0.0880,0.488]	0.96
ρ_z	0.622	[0.487,0.744]	0.58	0.708	[0.5741,0.828]	0.50
ρ_g	0.751	[0.637,0.845]	0.58	0.790	[0.6316,0.890]	0.26
ρ_c	0.689	[0.458,0.875]	0.37	0.547	[0.3648,0.726]	0.21
σ_z^2	0.034	[0.028,0.043]	0.91	0.036	[0.0289,0.044]	0.79
σ_g^2	0.040	[0.031,0.052]	0.26	0.029	[0.0213,0.039]	0.83
σ_c^2	0.128	[0.082,0.201]	0.89	0.189	[0.1056,0.370]	0.45
			SOUTH AFRICA			
		BENCHMARK			**LIABILITY DOLLARISATION**	
ψ	1.664	[1.115,2.668]	0.31	0.275	[0.1578,0.420]	0.93
ρ_z	0.918	[0.874,0.958]	0.50	0.782	[0.6795,0.863]	0.92
ρ_g	0.827	[0.767,0.886]	0.86	0.797	[0.6900,0.869]	0.95
ρ_c	0.626	[0.442,0.815]	0.43	0.654	[0.4663,0.798]	0.59
σ_z^2	0.015	[0.014,0.018]	0.85	0.020	[0.0172,0.023]	0.91
σ_g^2	0.012	[0.010,0.014]	0.22	0.016	[0.0123,0.021]	0.86
σ_c^2	0.082	[0.059,0.110]	0.34	0.086	[0.0579,0.137]	0.56
			TURKEY			
		BENCHMARK			**LIABILITY DOLLARISATION**	
ψ	4.067	[2.743,4.830]	0.50	0.455	[0.1259,1.182]	0.86
ρ_z	0.691	[0.552,0.803]	0.25	0.648	[0.5124,0.763]	0.24
ρ_g	0.629	[0.508,0.741]	0.46	0.705	[0.5614,0.811]	0.10
ρ_c	0.646	[0.428,0.822]	0.49	0.507	[0.3384,0.655]	0.48
σ_z^2	0.062	[0.049,0.078]	0.87	0.059	[0.0455,0.075]	0.49
σ_g^2	0.080	[0.060,0.107]	0.14	0.074	[0.0528,0.101]	0.66
σ_c^2	0.201	[0.114,0.384]	0.12	0.192	[0.1026,0.428]	0.20
			DEVELOPED ECONOMIES			
		CANADA			**SWEDEN**	
ψ	2.335	[1.646,3.573]	0.14	2.490	[1.486,4.103]	0.89
ρ_z	0.901	[0.852,0.948]	0.38	0.885	[0.829,0.939]	0.95
ρ_g	0.757	[0.676,0.832]	0.91	0.597	[0.488,0.706]	0.15
ρ_c	0.920	[0.860,0.958]	0.53	0.738	[0.523,0.878]	0.53
σ_z^2	0.013	[0.011,0.015]	0.70	0.022	[0.018,0.025]	0.46
σ_g^2	0.009	[0.008,0.011]	0.56	0.018	[0.015,0.022]	0.80
σ_c^2	0.047	[0.038,0.058]	0.88	0.074	[0.055,0.102]	0.55
		SWITZERLAND				
ψ	0.165	[0.141,0.193]	0.54			
ρ_z	0.880	[0.826,0.931]	0.55			
ρ_g	0.596	[0.486,0.699]	0.52			
ρ_c	0.697	[0.515,0.835]	0.92			
σ_z^2	0.014	[0.013,0.016]	0.48			
σ_g^2	0.012	[0.010,0.014]	0.89			
σ_c^2	0.093	[0.067,0.129]	0.25			

Notes: Results are based on 150,000 draws from the posterior distribution of which for EMEs the first 100,000 and for developed economies the first 125,000 draws were burned. To avoid autocorrelation issues, we only keep every 10$^{\text{th}}$ draw for developed economies, and every 25$^{\text{th}}$ for EMEs. The χ^2 figure denotes the p–value of Geweke's χ^2–test for convergence (4% taper). Variances are reported in percentages.

across models. For instance, evaluated at the median of the posterior distribution, a slight increase in the external debt to income ratio of merely one percentage point lifts the cost of borrowing by as much as 4.34 percentage points in the benchmark economy, whereas in the extended model interest rates rise by only 0.22 percentage points. In light of this simple numerical exercise, the model with foreign currency debt seems to deliver debt–elasticities that are more reasonable in terms of their economic significance.

Looking at the benchmark economy, our estimation results suggest that the magnitude of reduced form financial frictions is more severe in EMEs than in developed economies. In fact, apart from South Africa, the mode of the posterior distribution of ψ obtained for EMEs is greater than its counterpart in the group of developed countries. In general, our findings for EMEs are to some extent consistent with the results reported by García-Cicco *et al.* (2010). On the one hand, our estimates for Mexico and Turkey in the benchmark model indicate a perceptibly higher debt–elasticity of the interest rate compared to their study's findings for Argentina. On the other hand, the elasticity obtained in the liability dollarisation framework is lower for all three EMEs than the one documented by García-Cicco *et al.* (2010).

Turning to the parameters of the structural processes, we find that autocorrelation coefficients tend to be relatively high. This is especially the case for South Africa. By and large, however, we do not find large differences in the persistence parameters both across models and countries. For the group of emerging markets, the median of ρ_g, the parameter governing the persistence of the non–stationary productivity process, ranges from about 0.6 to 0.8. These estimates are clearly higher than those reported by Aguiar and Gopinath (2007) and García-Cicco *et al.* (2010). Nonetheless, they fall into the range of the results obtained by Chang and Férnandez (2013) and Boz *et al.* (2011) for Mexico as well as Nguyen (2011) for the United States.

Interestingly, the variances of our structural shocks seem to differ between models and country groups. Estimated variances of the two technology processes are generally higher in EMEs than in advanced economies. Aguiar and Gopinath (2007) highlight the necessity of a high standard deviation of the permanent relative to transitory productivity shock in their model in order to account for certain business cycle phenomena in EMEs. In the benchmark model, we indeed find a higher ratio of volatilities $\frac{\sigma_g}{\sigma_z}$ for EMEs, except South Africa, than for developed economies. However, our estimation exercise suggests a much lower relative volatility of trend shocks in EMEs compared to Aguiar and Gopinath (2007).[25] What is more, we find that the ratio of standard deviations at the median of the posterior is even lower in the model with liability dollarisation than in the benchmark model for Mexico and Turkey, while it is the same in both model versions for South Africa.[26] Nonetheless, as we will demonstrate in Section 3.6, our model with liability dollarisation performs reasonably well in matching business cycle patterns in EMEs despite a relatively low $\frac{\sigma_g}{\sigma_z}$.

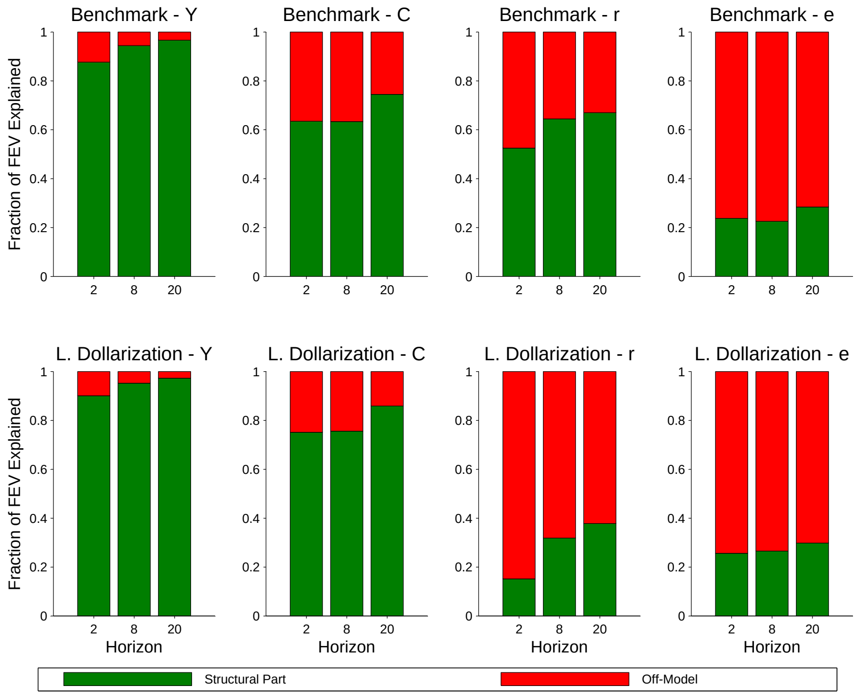
3.5.2 Model Fit

Next, we analyse the importance of the structural part relative to the off–model part in driving the dynamics of the observable variables. For this purpose, Figure 3.3 depicts the fraction of the forecast error variance attributed to structural shocks, i.e. permanent and transitory technology as well as foreign demand shocks, confronted to the fraction explained by the off–model dynamics. While evaluating the respective setup at the median of the posterior distribution, we compute the mean forecast error variance decomposition across all EMEs in both the benchmark economy and the model with liability dollarisation. This allows us to study the extent to which our structural model is able to capture the dynamics in our observables. Hence, we can easily assess and compare the fit of our two

[25]Looking at the median of the posterior distributions, we calculate a ratio of volatilities $\frac{\sigma_g}{\sigma_z}$ equal to 0.8321, 0.9045, and 0.9258 for Canada, Sweden, and Switzerland, respectively. In the benchmark (liability dollarisation) model, we get a ratio of 1.0847 (0.8975) for Mexico, 0.8944 (0.8944) for South Africa, and 1.1359 (1.1199) for Turkey. For a comparison, GMM estimates obtained by Aguiar and Gopinath (2007) imply ratios as high as 4.0189 for Mexico and as low as 0.7460 for Canada. To gauge the relative importance of trend shocks, these authors calculate the random walk component of the Solow residual, which also takes the persistence of shocks into account. The size of the random walk component in our estimation can be found in Appendix B.

[26]What is striking is that estimation results for South Africa are in various aspects different from those obtained for Mexico and Turkey. This peculiarity might be explained by the fact that in contrast do other emerging markets, South Africa has had deep and well developed financial markets for decades. Also, as pointed out by Eichengreen and Hausmann (2005), it is one of the few emerging markets which traditionally has been able to issue bonds denoted in their own currency on international capital markets.

Figure 3.3: Forecast Error Variance Decomposition – Model Comparison



Notes: Mean forecast error variance decomposition across all EMEs. Results are based on median outcomes of the respective posterior distributions.

setups.

The graph reveals that the liability dollarisation setup outperforms the benchmark model in accounting for the variation in output, consumption, and real exchange rates at all forecast horizons. The superiority of the framework with liability dollarisation is most perceivable for consumption. Yet we also observe that the benchmark model explains a larger portion of the variability in real interest rates. We explain this peculiar result for the real interest rate by a change in the importance of interest rate shocks once we augment the model with liability dollarisation. Recall that both our models abstract from any exogenous disturbances in the interest rate like world interest rate or country premium shocks. Nonetheless, our estimation procedure implicitly controls for such interest rate shocks by the inclusion of a dynamic measurement error. In light of this interpretation, our exercise suggests that once countries can only borrow in foreign currency, interest rate shocks apparently become more important.[27] By and large, we therefore infer

[27]Neumeyer and Perri (2005), Uribe and Yue (2006), García-Cicco *et al.* (2010), and Chang and Férnandez (2013) have augmented their SOE models with interest rate shocks. These authors

that the model with liability dollarisation fits the data in EMEs better than the benchmark setup.

Furthermore, estimation results are generally in strong favour of our theoretical framework. Though being quite stylised, the structural model performs very well, especially in capturing the dynamics of the main macroeconomic aggregates, i.e. output and consumption. Regarding exchange rates, we observe that only about 20 to 30 percent of the variation can be attributed to shocks specified in the theoretical model. This finding is owed to the fact that our models cannot produce exchange rate volatilities as high as we observe in the data.

3.6 Model Analysis

This section examines in how far our theoretical model helps us in understanding macroeconomic dynamics in emerging markets. As the previous section has demonstrated, the model with liability dollarisation outperforms the benchmark setup in fitting the data. Hence, we confidently treat the liability dollarisation framework as the more appropriate model for EMEs and focus on the analysis of the extended setup for this country group. For comparison, we analyse the benchmark model for EMEs in Appendix B.

We begin with implementing a forecast error variance decomposition (FEVD) to assess the relative importance of different shocks in explaining macroeconomic fluctuations. We then turn to an impulse response analysis of the three structural shocks in our liability dollarisation setup. Subsequently, we compare model implied business cycle moments with their empirical counterparts to demonstrate that our model succeeds in replicating various stylised business cycle facts. Finally, we show the model's ability to account for the sudden stop in Mexico's capital inflows during the Tequila Crisis of 1994–1995.

stress the merits of this model extension for explaining macroeconomic fluctuations in emerging markets. In particular, Chang and Férnandez (2013) show that interest rate shocks are amplified by financial frictions. This underpins our finding that the off–model dynamics of interest rates play a greater role in the setup with liability dollarisation.

3.6.1 Forecast Error Variance Decomposition

In what follows, we study the relative contribution of various shocks in driving the dynamics in our theoretical economy. For this purpose, we perform a forecast error variance decomposition of the structural part of our model evaluated at the median of the posterior distributions for each country.

Figures 3.4 and 3.5 plot the average FEVD of selected variables across all EMEs and developed countries, respectively.[28] Certain patterns are worth emphasising. First, in both emerging markets and developed countries, transitory shocks are the driving force behind output in the short–run. Looking at the developed world, we observe this particular feature not only in the short–run but also in the long–run. In EMEs, on the contrary, the permanent productivity process gains importance over longer horizons and eventually becomes the major determinant of output fluctuations in the long–run. Moreover, in both cohorts, trend shocks predominantly account for consumption variation over all forecast horizons. But permanent shocks are relatively more important for consumption fluctuations in EMEs than in advanced economies.

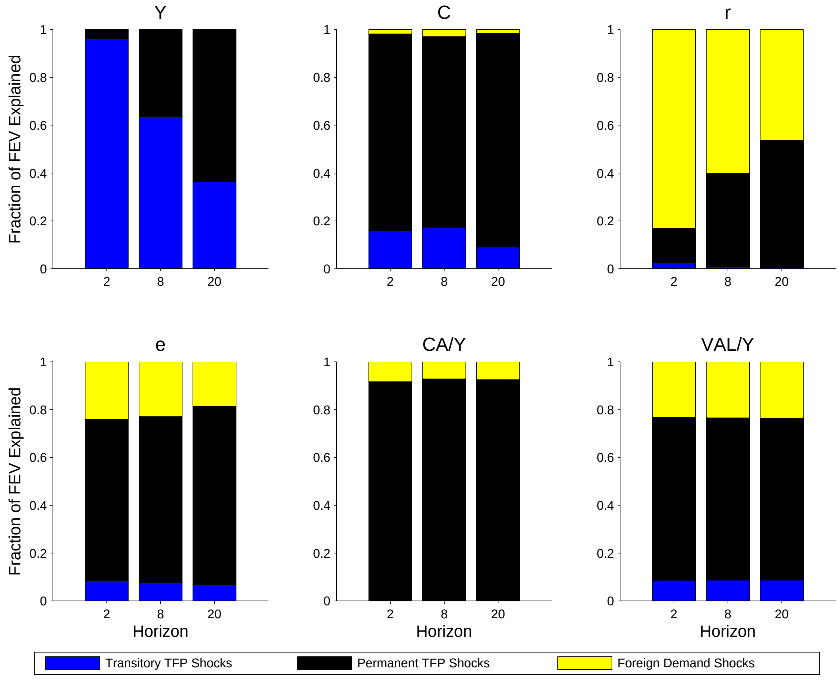
Second, transitory technology disturbances generally play a minor role for the dynamics in the cost of borrowing. It is essentially growth shocks that account for interest rate variations in advanced countries. In EMEs, however, foreign demand shocks also seem to govern interest rate dynamics to a non–negligible extent, especially in the short–run. This finding indicates that changes in external demand may have important feedback effects on the interest rate in emerging markets.

Third, both transitory productivity and foreign demand disturbances explain a considerable share of the variation in the real exchange rate in industrialised economies. By contrast, it is permanent shocks that dominate relative international price movements in EMEs over all forecast horizons.

Finally, this predominance of trend shocks in emerging markets is even more striking if we look at the FEVD of the current account to output ratio. Figure 3.4 suggests that virtually all fluctuation in $\frac{CA}{Y}$ can be attributed to permanent

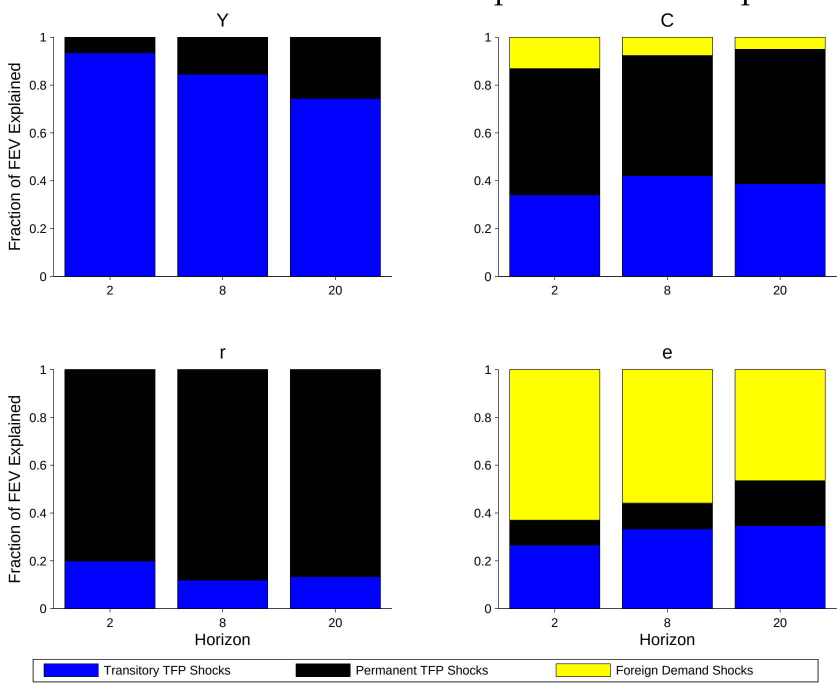
[28] Forecast error variance decompositions for all six countries, as well as for both models for the cohort of EMEs, can be found in the Appendix B.

Figure 3.4: Forecast Error Variance Decomposition – Emerging Market Economies



Notes: Mean forecast error variance decomposition across all EMEs for the model with liability dollarisation. Results are based on median outcomes of the respective posterior distributions.

Figure 3.5: Forecast Error Variance Decomposition – Developed Economies



Notes: Mean forecast error variance decomposition across all developed countries. Results are based on median outcomes of the respective posterior distributions.

productivity shocks. Similarly, more than 60 percent of the forecast error variance of the valuation effects to GDP ratio is determined by innovations to the non–stationary technology process. Foreign demand shocks account for about one third of the variation in $\frac{VAL}{Y}$, while the influence of transitory technology shocks again is trifling.

In a nutshell, our exercise suggests that transitory productivity shocks are far more important in explaining fluctuations of macroeconomic aggregates in industrialised countries compared to EMEs. As opposed to García-Cicco *et al.* (2010) and Chang and Férnandez (2013), we conclude that even though we account for financial frictions in our model, both transitory and, above all, permanent disturbances play a role in explaining business cycle variations in EMEs. This in turn is concurrent with the findings of Aguiar and Gopinath (2007) who argue that macroeconomic fluctuations in EMEs are mainly driven by trend shocks. Thus, we largely find support for their famous hypothesis that *"the cycle is the trend"*.[29]

3.6.2 Impulse Response Analysis

Next, we shed more light on the mechanics of our model describing EMEs. To this end, we parametrise the liability dollarisation setup at the median of the posterior distributions and compute impulse responses to the three structural shocks for each country.

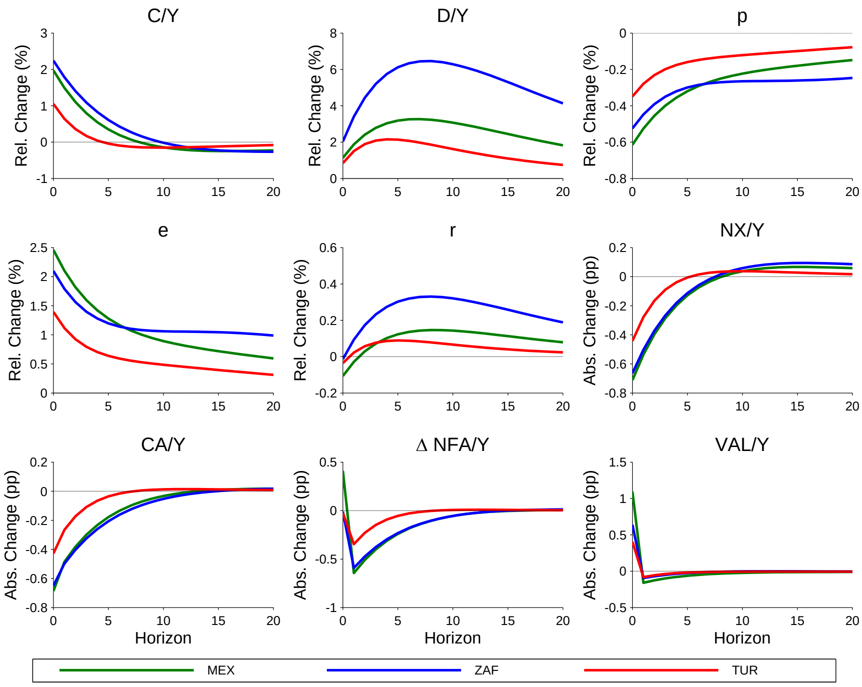
Permanent versus Transitory Productivity Shocks

Figures 3.6 and 3.7 plot selected impulse responses to a one percent permanent and transitory productivity disturbance, respectively.

A positive trend shock leads to an increase in consumption and foreign debt relative to income. On the contrary, the effects on $\frac{C}{Y}$ and $\frac{D}{Y}$ are reverse following a positive transitory shock. These opposite responses follow from the optimal savings behaviour of the representative consumer and have the same interpretation

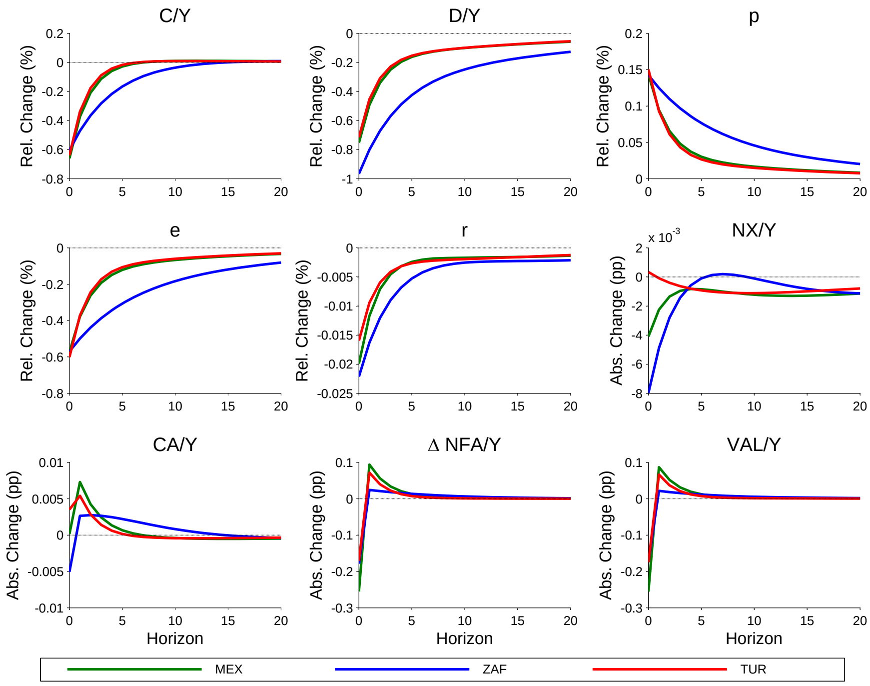
[29] In a recent study, Naoussi and Tripier (2013) estimate the framework of Aguiar and Gopinath (2007) for a number of developed, emerging markets, and developing economies. They find that permanent shocks are much more important in developing countries and emerging markets than in advanced economies. Therefore, their results corroborate the notion that *"the cycle is the trend"*, too.

Figure 3.6: Impulse Responses – Permanent Shock



Notes: Impulse responses to a one percent permanent productivity shock in the model with liability dollarisation for all EMEs evaluated at the median of the respective posterior distribution.

Figure 3.7: Impulse Responses – Transitory Shock



Notes: Impulse responses to a one percent transitory productivity shock in the model with liability dollarisation for all EMEs evaluated at the median of the respective posterior distribution.

as in the model of Aguiar and Gopinath (2007). After a positive growth shock, households do not only realise higher income today but also anticipate higher income in the future. The expectation of higher future income is due to the fact that (i) the positive impact on productivity is permanent and does not vanish over time, (ii) adjustment costs imply a gradual change in capital, and (iii) in addition, growth shocks are persistent ($\rho_g > 0$). Since agents prefer a smooth consumption path over time, it is optimal to raise consumption by more than the initial increase in output. In fact, households borrow on international capital markets in order to finance their optimal consumption plan and additional investment, which explains the excess response of debt relative to GDP. In contrast, this consumption smoothing rationale also induces households to curb international borrowing, i.e. to save after a positive transitory shock, because income is expected to revert to its long–run equilibrium path in the future. As a result, consumption reacts less strongly than output, such that $\frac{C}{Y}$ falls on impact.

A permanent shock also reduces the price of the composite consumption good p, whereas a temporary productivity innovation raises the price level. This can be explained as follows. Positive technology shocks lead to instantaneous jumps in income. As explained above, if shocks are permanent, people do not only benefit from higher income today but also anticipate even higher income in the future. Hence, households sharply raise their demand for home–produced goods (in form of consumption and investment) on impact. This increase in demand actually overshoots the initial rise in supply, which drives up the price of home–produced goods. As a consequence, the relative price of composite consumption expressed in terms of home–produced goods p falls. On the contrary, the initial increase in demand falls short of the one in supply after a transitory shock, such that the price of home–produced goods must decline in equilibrium and the relative price of total consumption p rises.

Due to imperfect substitutability between home and foreign goods the relative change of the domestic price of the foreign good p_F must always be stronger than the one of the price of the overall consumption index p. This follows immediately from the definition of the price index in equation (3.9). As a consequence, the real exchange rate in equation (3.14) appreciates (depreciates) following a positive trend (transitory) productivity shock.

The response of the real interest rate is in principle ambiguous. A higher expected debt to income ratio after a permanent shock puts an upward pressure on the interest rate. At the same time, however, the associated real appreciation reduces the debt burden, which dampens the increase in the interest rate. Interestingly, our results suggest that the real appreciation effect outweighs the debt to income ratio effect in the case of Mexico, while the effects largely offset each other in South Africa and Turkey. Regarding the reaction after a temporary productivity shock, we witness a fall in the real interest rate in all three countries.

Irrespective of its nature, a positive productivity shock induces households to consume more. Consequently, consumption of both home and foreign goods goes up, too. As described above, the price of foreign goods relative to home goods p_F falls after a positive trend shock. This means that the rest of the world experiences a real depreciation and thus demands less goods produced in the home country $c_H^{\star}$ (see equation (3.15)). In sum, the home country exports less, while at the same time the value of its imports increases, such that net exports decline. In contrast, domestic exports rise after a transitory shock because of a real appreciation abroad. Hence, the increase in both imports and exports leave the overall impact on the trade balance unclear. In our exercise at hand, these two counteracting effects largely cancel out, such that we observe a rather weak response of the net exports to output ratio.

The deterioration of the trade balance together with higher interest payments on foreign debt translates into a worsening of the current account to income ratio after a trend shock. Furthermore, the associated real appreciation reduces the amount of outstanding foreign debt and therefore initially generates positive valuation effects (see equation (3.26)). The change in the net foreign asset position in (3.22) is given by the sum of the current account and valuation effects. As a result, positive valuation effects in fact dampen the negative change in foreign assets induced by the fall in the current account. In the case of Mexico, these valuation effects exceed the drop in the current account, such that the value of net foreign assets actually goes up on impact.

The response of $\frac{CA}{Y}$ to a transitory shock is slightly positive in Mexico and

Turkey, but negative in South Africa. In Mexico, for instance, the fall in interest payments on foreign debt obligations more than compensates the deterioration of the trade balance, such that there is a positive reaction of the current account. Likewise, the real depreciation leads to negative valuation effects, which have a negative impact on the net foreign asset position. What is striking is that these external balance sheet effects are strong enough to generate a fall in net foreign assets in countries where we observe an initial increase in the current account, namely Mexico and Turkey.

Foreign Demand Shock

Figure 3.8 displays impulse responses to a one percent increase in foreign consumption. By and large, outcomes do not vary substantially across countries.

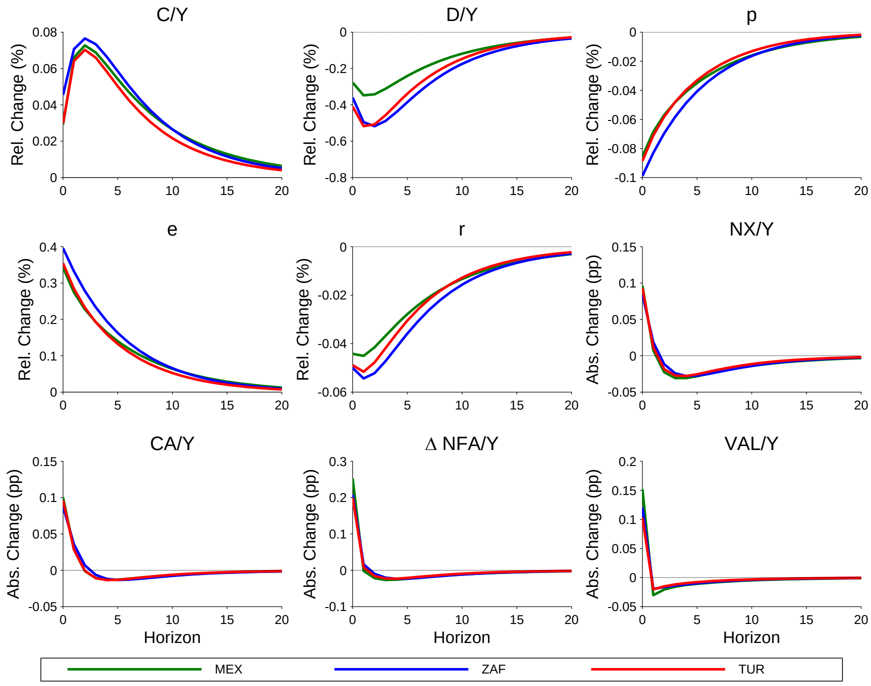
A positive shock to foreign consumption $c^{\star}$ directly translates into a rise in domestic exports $c_H^{\star}$. Consequently, net exports increase on impact. Furthermore, higher demand for domestically produced goods, *ceteris paribus*, puts an upward pressure on the price of home goods such that the relative prices of foreign goods p_F and composite consumption p fall. Since the relative drop in p_F prevails the decrease in p, the real exchange rate appreciates.

The favourable movement in the real exchange rate entails a positive wealth effect, which induces domestic households to consume more. As a matter of fact, the relative increase in consumption c is larger than the one in output y, such that the consumption to GDP ratio rises.[30] Also, households substitute consumption of relatively more expensive home goods c_H for relatively cheaper foreign goods c_F. This somewhat dampens the positive reaction of the trade balance and explains its reversal in the periods after the shock.

In addition, the external debt to income ratio falls. Although consumption becomes cheaper, real appreciation drives up the price of consumption today expressed in units of consumption tomorrow (see equation (3.22)). Agents know that the demand shock is only temporary and anticipate a real depreciation in the future. Therefore, they have an incentive to save more, i.e they reduce their

[30]The increase in output initiated by higher foreign demand for home–produced goods is dampened by lower domestic absorption (i.e. lower domestic consumption of the home good and lower investment).

Figure 3.8: Impulse Responses – Foreign Demand Shock



Notes: Impulse responses to a one percent foreign demand shock in the model with liability dollarisation for all EMEs evaluated at the median of the respective posterior distribution.

international debt holdings.[31] A lower $\frac{D}{Y}$, along with an appreciated real exchange rate, pushes down the real interest rate. The resulting cut in interest payments plus higher net exports lead to an increase in the current account, which in turn increases the domestic foreign asset position. Positive valuation effects, originated by real appreciation, eventually boost the improvement of the external balance sheet.

Stabilising or Destabilising Valuation Effects?

Our impulse response analysis illustrates that the impact of valuation effects on the net foreign asset position depends on the nature of the underlying shock. On the one hand, valuation effects mitigate the change in net foreign assets induced by the decline in the current account following a permanent productivity shock. Hence, they have a stabilising impact on the external balance sheet in this case. On the other hand, valuation effects amplify the influence of the current account on

[31] We can think of domestic households investing in foreign goods by reducing the amount of international debt. In other words, they go long in foreign goods.

net foreign assets after a foreign demand shock. Regarding transitory technology shocks, the effect is generally unclear. In our exercise, transitory productivity shocks entail external balance sheet effects that counteract the reaction of the current account in Mexico and Turkey, but reinforce it in South Africa. Having said this, our findings conflict with the implications of the model of Nguyen (2011), which predicts stabilising (amplifying) valuation effects after a transitory (permanent) technology shock.

3.6.3 Business Cycle Moments

In this subsection, we gauge our structural model's ability to reproduce various business cycle patterns. To this end, we simulate the respective model evaluated at the median of the posterior distributions for each country. We generate data covering a time span of 100 periods and subsequently compute various moments based on the detrended series of our variables. On the whole, we repeat this exercise 5,000 times. Table 3.6 compares empirical moments with their model generated counterparts, which correspond to the median across all simulations. Empirical moments are calculated using quarterly real data from the IFS, apart from those involving valuation effects for which only annual data from Lane and Milesi-Ferretti (2007) are available. All series, except for the net exports to output ratio and valuation effects, have been logged, seasonally adjusted and filtered using the HP filter with smoothing parameter 1,600.

Consistent with the data, the model predicts generally higher standard deviations of income, consumption, and the net exports to output ratio in EMEs than in advanced economies. Hence, our theoretical economy can well account for the empirical regularity that macroeconomic fluctuations are more severe in emerging markets as compared to developed countries.

Furthermore, the model is not only able to generate excess volatility in consumption relative to output in EMEs, but also matches relative consumption volatilities in advanced countries quite well. This observation raises the question of why? On the one hand, as shown in Section 3.6.1, our estimation results suggest that macroeconomic dynamics in EMEs are predominantly driven by the

Table 3.6: Business Cycle Moments

	Data	Model	Data	Model	Data	Model
	Emerging Market Economies					
	Mexico		**S. Africa**		**Turkey**	
$\sigma(Y)$	2.42	5.31	1.60	4.25	3.70	6.30
$\sigma(C)$	3.68	6.71	2.46	5.08	5.72	7.65
$\sigma(NX/Y)$	6.63	1.58	4.04	0.95	3.42	1.46
$\sigma(e)$	9.63	7.71	8.70	5.05	9.54	7.47
$\sigma(C)/\sigma(Y)$	1.52	1.57	1.54	1.41	1.55	1.45
$\rho(NX/Y, Y)$	−0.17	−0.10	−0.40	−0.19	−0.56	−0.27
$\rho(e, NX/Y)$	−0.31	−0.62	−0.12	−0.43	−0.45	−0.48
$\rho((NX/Y)_t, (NX/Y)_{t-1})$	0.97	0.69	0.85	0.67	0.84	0.57
$\rho((VAL/Y)_t, (CA/Y)_t)$	−0.58	−0.34	−0.75	−0.30	−0.05	−0.38
$\rho((VAL/Y)_t, e_t)$	0.45	0.29	−0.31	0.28	0.19	0.30
	Developed Economies					
	Canada		**Sweden**		**Switzerland**	
$\sigma(Y)$	1.42	4.13	1.75	4.57	1.76	3.68
$\sigma(C)$	1.36	4.12	1.51	4.00	1.44	3.11
$\sigma(NX/Y)$	1.96	0.54	2.77	0.45	3.74	0.65
$\sigma(e)$	3.41	5.34	8.81	4.61	7.94	5.53
$\sigma(C)/\sigma(Y)$	0.96	1.00	0.86	0.77	0.82	0.71
$\rho(NX/Y, Y)$	0.01	−0.36	−0.01	−0.39	−0.17	0.27
$\rho(e, NX/Y)$	−0.03	−0.21	−0.07	−0.14	−0.02	−0.59
$\rho((NX/Y)_t, (NX/Y)_{t-1})$	0.93	0.28	0.94	0.15	0.84	0.49

Notes: Standard deviations are expressed in percentages except for the model implied standard deviation of the net exports to output ratio, which is expressed in percentage points. All series, except for the net exports over output ratio and valuation effects, are real per capita variables, have been logged, seasonally adjusted and filtered using the HP filter with smoothing parameter $\lambda = 1{,}600$. Theoretical moments are based on sample moments of model generated data. For the group of EMEs, we have used the liability dollarisation framework. Each theoretical economy is simulated 5,000 times with a sample size of 100. Median outcomes are reported.

non–stationary productivity component. On the other hand, the preceding subsection has demonstrated that consumption overshoots output after a permanent technology shock. It is the interplay of these two features that explains the excess volatility of consumption.

Our model also succeeds in generating a negative correlation between the net exports to GDP ratio and income in EMEs. Yet it struggles to match this moment from a quantitative point of view. In fact, the model understates the countercyclicality of the net exports to output ratio in EMEs, but it also overstates this countercyclicality for the cohort of advanced economies, except Switzerland. Recall that permanent technology shocks induce households to purchase more foreign goods, while the real depreciation experienced by the rest of the world cuts the external demand for home goods. This leads to a deterioration of the home country's trade balance and explains why our model generates a negative correlation between the net exports to GDP ratio and income. The fact that we cannot replicate the high degree of countercyclicality of $\frac{NX}{Y}$ in EMEs is due to the relatively persistent non–stationary productivity process. Indeed, the higher the autocorrelation of the permanent technology process, the weaker the countercyclicality of the trade balance. As a matter of fact, if trend shocks are persistent enough, the income effect on labour supply induces households to work less after a positive permanent shock. In this scenario, output falls, which actually implies a positive correlation between income and net exports.[32]

Our model suggests that real exchange rates are in general more volatile in EMEs than in developed economies. This prediction is in line with what we observe in the data. Furthermore, the model reproduces the negative correlation between the real exchange rate and the net exports to output ratio in EMEs. In contrast, the benchmark model has difficulties in replicating the weak relationship between these two variables in the group of industrialised countries.

A key contribution of the paper by García-Cicco *et al.* (2010) is that their model can account for the empirically observed downward sloping autocorrelation function of $\frac{NX}{Y}$. Interestingly, our benchmark model exhibits a fairly low first–order serial correlation of the net exports to income ratio in developed economies, whereas the liability dollarisation setup matches this moment better for EMEs. As García-Cicco *et al.* (2010) point out, it is important to allow for a ψ that is significantly different from zero in order to obtain a falling autocorrelation function of $\frac{NX}{Y}$. The reason for that is as follows. For instance, after a positive permanent shock, households increase their international debt holdings and run a trade balance deficit. In case of a high debt–elasticity ψ, the rise in debt relative to GDP in turn raises the real interest rate. This induces households to consume less and save more, which leads to an improvement of the trade balance. On the other

[32] Accordingly, our model's weak performance regarding the countercyclicality of the trade balance might be explained by our preference specification. As we have already mentioned in Section 3.3, our choice of Cobb–Douglas period utility implies an income effect on labour supply. In contrast, other researchers in this strand of the literature use GHH preferences, which do not feature income effects on labour supply.

hand, if ψ is close to zero (as for example in the calibration of Aguiar and Gopinath (2007)) the feedback effect of changes in $\frac{D}{Y}$ on the cost of borrowing is virtually shut down, which results in an autocorrelation function of $\frac{NX}{Y}$ that resembles a near unit root process. In fact, our estimates of ψ in the benchmark economy are quite high compared to our liability dollarisation framework. This might help us to explain why the model understates the first–order autocorrelation of $\frac{NX}{Y}$, especially for advanced economies.

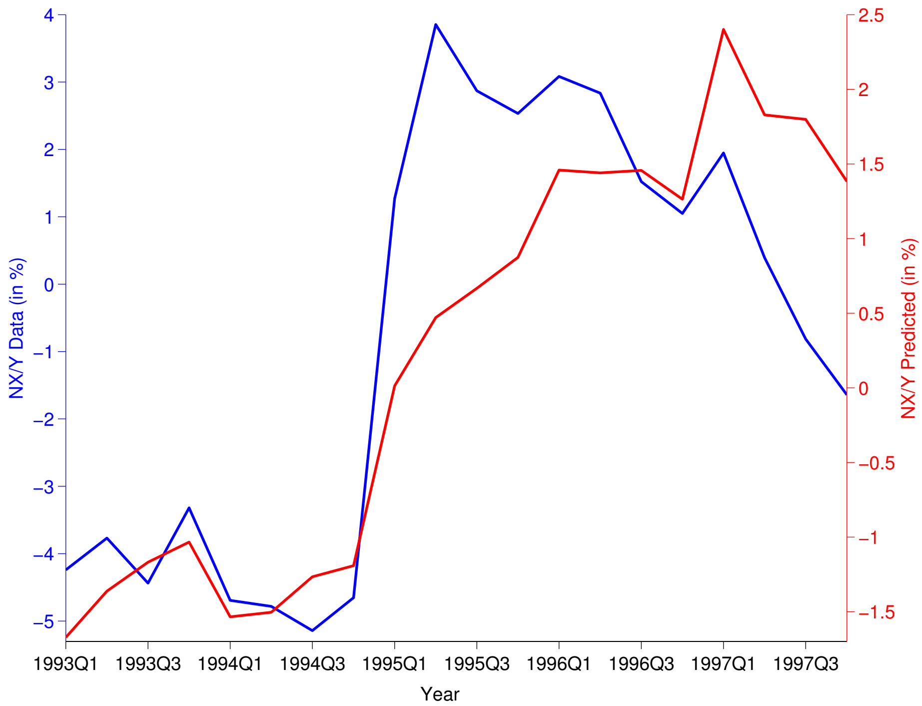
Table 3.6 also provides meaningful insights with respect to the role of valuation effects in EMEs. Not surprisingly, they are positively correlated with the real exchange rate in our model. This feature is consistent with our descriptive findings for Mexico and Turkey. More importantly, our model predicts a negative relationship between valuation effects and the current account in all three EMEs. As a matter of fact, this is line with the negative correlation between $\frac{VAL}{Y}$ and $\frac{CA}{Y}$ in the data, especially for Mexico and South Africa. Consequently, we find that, on average, valuation effects have a stabilising impact on the net foreign asset position. In light of our discussion in Section 3.6.2, this outcome can be explained by the fact that EMEs are predominantly exposed to trend shocks.

3.6.4 Mexico's Tequila Crisis

Finally, we investigate the performance of our model in crisis times. Over the last two decades, many EMEs have experienced severe balance of payments (BOP) crises, such as Mexico during the Tequila crisis of 1994–1995; Indonesia, Korea, Malaysia, the Philippines, and Thailand during the Asian crisis of 1997; or Argentina in 2001. A typical feature of BOP crises in emerging markets is the sudden stop in capital inflows, which usually brings about a reversal in current accounts and net exports, a drop in output, consumption, and investment, as well as exchange rate depreciations (see Mendoza (2010)).

In what follows, we examine whether our theoretical framework is capable of replicating Mexico's sudden stop during the Tequila Crisis of 1994–1995. To do so, we adopt a similar approach as in Aguiar and Gopinath (2007). We calibrate our liability dollarisation model at the median of the posterior distributions for

Figure 3.9: Mexico's Tequila Crisis of 1994–1995



Notes: Actual versus predicted net exports to output ratio for the Mexican economy between the first quarter of 1993 and the fourth quarter of 1997.

Mexico. We use data on output, consumption, real interest rates, and real exchange rates and implement the Kalman filter to generate the unobservable state variables. Subsequently, we feed the obtained states into the model to compute time series for our control variables.

Figure 3.9 shows the true and predicted net exports to output ratio in Mexico between 1993Q1 and 1997Q4. As is evident from the figure, our model can reproduce the reversal in the Mexican trade balance between 1994 and 1995. At a first glance, however, our model seems to struggle to quantitatively match the dramatic change in $\frac{NX}{Y}$. It predicts an increase in the net exports to output ratio by 2.2 percentage points between the third quarter of 1994 and the second quarter of 1995, whereas the actual net exports to output ratio increased by as much as 7.7 percentage points. Note, however, that the steady state level of the trade balance to GDP ratio is much lower than its empirical counterpart.[33]. If we look at the

[33]Recall from Section 3.4.2 that we do not pin down the steady state net exports to output ratio

change of $\frac{NX}{Y}$ relative to its long–run mean rather than the absolute change, we actually find that our model performs quite well also from a quantitative point of view.

The remaining question is then why does our framework succeed in explaining the sudden stop in capital flows. The shock series produced by the Kalman filter indicate that the Mexican economy was hit by a strong negative permanent shock in the fourth quarter of 1994. As we have discussed in Section 3.6.2, a negative trend shock leads to an increase in the net exports to output ratio. In addition, a large negative permanent shock causes a sharp fall in output and consumption, as well as a real depreciation, which is also in line with what we observe in the data. What is more, our liability dollarisation model suggests that sudden stops are associated with negative valuation effects. As a result, balance sheet effects actually dampened the increase in Mexico's net foreign asset position during the Tequila crisis according to the model.

3.7 Conclusion

We develop a small open economy DSGE model featuring a non–stationary productivity process, differentiated home and foreign goods, and endogenous exchange rate movements to study the importance of financial frictions and trend shocks in explaining macroeconomic dynamics in EMEs. We also extend our benchmark setup and introduce liability dollarisation as a special form of financial market distortions in emerging markets. This model modification allows us to analyse the impact of valuation effects on the external balance sheet in these countries.

In the empirical part of the paper, we estimate our model using Bayesian techniques for a group of EMEs. Furthermore, in order to investigate the difference between emerging and advanced economies, we perform our estimation exercise also for a group of developed countries. We account for off–model dynamics by allowing for a (vector–)autoregressive measurement error in our estimation procedure. As a matter of fact, this constitutes to a novel approach in this strand

in our calibration exercise.

of the literature.

Our results show that the co–existence of financial frictions and trend shocks helps to explain macroeconomic dynamics in EMEs. In particular, incorporating liability dollarisation in our framework improves the model fit. Our analysis suggests that trend shocks are the driving force behind macroeconomic fluctuations in EMEs. Therefore, we find support for the famous hypothesis that *"the cycle is the trend"*, even though we include financial market distortions in our setup.

Our liability dollarisation model succeeds in replicating certain stylised facts about emerging market business cycles: (i) it predicts more severe macroeconomic fluctuations in EMEs than in developed countries, (ii) it matches the excess volatility of consumption relative to output, (iii) it qualitatively reproduces the countercyclicality of the net exports to output ratio, although it falls short to match this moment on a quantitative basis, and (iv) it can replicate the sudden stop of capital inflows during the Mexican Tequila Crisis between 1994 and 1995. Interestingly, our liability dollarisation framework suggests that valuation effects on average have a stabilising impact on the net foreign asset position in EMEs. In this vein, we also contribute to a currently active line of research on external balance sheet effects, which so far has mainly focused on developed economies.

Admittedly, the introduction of liability dollarisation as a from of financial frictions in our model is fairly simple. One could go one step further and study the implications liability dollarisation in the presence of other credit market distortions. In particular, we could build on the literature on credit frictions in macroeconomics (e.g. Kiyotaki and Moore (1997) and Bernanke *et al.* (1999)) and incorporate collateral constraints in the model. In that case, the amount of debt depends on the agent's net worth, which is subject to exchange rate variations due to liability dollarisation. It would then be interesting to see how the combination of amplification effects, resulting from the imposition of collateral constraints, and liability dollarisation affects macroeconomic dynamics in EMEs.

Chapter 4

Current Account Dynamics in Emerging Markets: Is the Cycle really the Trend?

4.1 Introduction

Macroeconomic fluctuations in Emerging Market Economies (EMEs) exhibit certain patterns which are distinct from those in advanced economies. For instance, business cycles in EMEs are more volatile than in the developed world, consumption volatility exceeds output volatility, and current accounts as well as net exports are strongly countercyclical. What is more, emerging markets are exposed to substantial reversals in international capital inflows. This observation is frequently referred to as the "sudden stop" phenomenon, a term introduced by Calvo (1998).[1]

A burgeoning number of studies have been devoted to investigate these common characteristics. One important line of research analyses real business cycle (RBC) Dynamic Stochastic General Equilibrium (DSGE) models of a small open economy (SOE) in the spirit of Mendoza (1991) to shed light on the macroeconomic dynamics in emerging markets. In a prominent contribution, Aguiar and Gopinath (2007) develop a stochastic growth model featuring both permanent and transitory productivity shocks. They estimate their model for two countries: Mexico and Canada, which represent emerging market and advanced econom-

[1] These stylised facts about business cycles in emerging markets have been documented by a large number of researchers. See, among others, Neumeyer and Perri (2005), Aguiar and Gopinath (2007), García-Cicco *et al.* (2010), Kose and Prasad (2010), and Chapter 3 of this thesis.

ies, respectively, in their analysis. Their findings suggest that macroeconomic fluctuations in Mexico are mainly driven by permanent shocks. In fact, this predominance of trend shocks explains the negative correlation between the current account and income, the excess volatility of consumption relative to output as well as the experience of a large current account reversal during the "Tequila Crisis" of 1994–1995. Conversely, their exercise also shows that transitory shocks are the key determinant of the Canadian business cycle. Hence, messrs Aguiar and Gopinath deduce the hypothesis that *"the cycle is the trend"* in emerging markets.

The findings of Aguiar and Gopinath (2007) have sparked a debate on the role of permanent shocks for business cycles in EMEs. While some contributions to the literature find support for this notion (see Naoussi and Tripier (2013) and Chapter 3 of this thesis), others provide contradictory evidence. In particular, an influential study by García-Cicco *et al.* (2010) challenges the conclusions drawn by Aguiar and Gopinath (2007). These authors highlight the importance of augmenting the SOE model with financial frictions in form of debt–elastic interest rates and country risk premium shocks in order to explain business cycles in EMEs. They estimate their model using very long time series of macroeconomic aggregates for Argentina. Indeed, they find that macroeconomic fluctuations in Argentina can almost completely be attributed to various transitory disturbances, whereas permanent shocks play only a negligible role. Similarly, a recent paper by Chang and Férnandez (2013) shows that the model with trend shocks does a poor job in matching the dynamics in macroeconomic data. Yet the introduction of certain financial frictions in their theoretical framework improves the model fit considerably. Likewise, Boz *et al.* (2011) analyse an SOE model in which households learn to differentiate between permanent and transitory shocks. They argue that the distinct business cycle patterns can be explained by more severe informational frictions in EMEs as compared to advanced economies.

Our paper uses a different approach to examine whether the cycle is really the trend in emerging markets. We follow the empirical literature on the intertemporal approach to the current account and employ a structural time series model.[2] Our

[2]See Obstfeld and Rogoff (1996) for the canonical models of the intertemporal approach to the current account. Furthermore, Obstfeld and Rogoff (1995) provide an early overview of both theory and empirics of the intertemporal approach.

analysis takes the theoretical framework of Aguiar and Gopinath (2007) as a point of departure. Their DSGE model imposes a cointegrating relationship between macroeconomic aggregates. We exploit this long–run equilibrium behaviour of the variables and scrutinise their hypothesis by estimating a structural Vector Error Correction Model (VECM) for a range of EMEs.

Many contributions to the empirics of the intertemporal approach emphasise the crucial role of the persistence of shocks and the distinction between global and country–specific disturbances for understanding current account dynamics (see Glick and Rogoff (1995), Hoffmann (2001b, 2003), Nason and Rogers (2002), and Corsetti and Konstantinou (2012)). For this reason, we build on the approaches of Hoffmann (2001a, 2013) and Kano (2008) and develop an identification scheme of the VECM to identify permanent and transitory as well as global and country–specific transitory shocks. In this vein, our study aims at bridging the gap between two important strands of the literature on international macroeconomics, which have hitherto been largely silent about each other, despite their apparent relatedness. On the one hand, there is the research on general equilibrium modelling to study business cycles in emerging markets. On the other hand, there is the empirical literature on the intertemporal approach to the current account.

Our analysis is based on a trivariate VECM which contains the world interest rate, the current account to output ratio, and GDP. This specification allows us to establish a technique to identify three structural shocks: permanent, global transitory, and country–specific transitory shocks. Before we take our identification method to the data, we gauge its strength. To this end, we apply it to model generated data. That is, we simulate the model of Aguiar and Gopinath (2007), extended by an exogenous world interest rate process, to generate artificial time series which we subsequently use to estimate our structural VECM. Indeed, we find that our methodology does a strikingly good job at extracting the true underlying shocks. In addition, the structural VECM succeeds in replicating the theoretically implied dynamics of the current account reasonably well.

Once we have validated our identification scheme, we implement it on data for 15 EMEs. A key finding of our empirical exercise is that there is no common explanation for the countercyclicality of the current account in emerging markets.

In only half of the countries in our sample, the countercyclicality of the current account results from permanent shocks, whereas country–specific transitory shocks account for this phenomenon in the other half of the countries. Interestingly, if a country exhibits a fall in the current account after a permanent shock, it also features an increase in the current account following an idiosyncratic transitory shock, and vice versa.

We show that we can to some extent explain this finding within the framework of the intertemporal model. Aguiar and Gopinath (2007) do not incorporate any explicit frictions in their model. But this does not mean that they completely ignore frictions in their analysis. They argue that market distortions appear in the Solow residual and manifest themselves in the permanent productivity process. According to Chari *et al.* (2007), we can then interpret the trend productivity component as a domestic efficiency wedge. Hence, we can think of countries in which permanent shocks lead to a fall in the current account as being mainly characterised by *domestic frictions*. On the other hand, if we augment the intertemporal model with distortions in international borrowing and lending, it can also predict a fall in the current account after a transitory shock. Thus, *international frictions* might be more prevalent in those EMEs which exhibit a negative response of the current account to idiosyncratic transitory disturbances. This interpretation, in turn, is consistent with the story of García-Cicco *et al.* (2010) and Chang and Férnandez (2013).

However, our empirical impulse response analysis also reveals a puzzle. In several EMEs, a permanent shock leads to a capital outflow rather than a capital inflow. At the same time, the short–run rise in income undershoots its long–run increase after a trend shock in these countries. As a result, the observed joint dynamics of the current account and output are not consistent with the implications of the standard intertemporal model. That said, we need to think about how we can enrich the model in order to explain this particular reaction of the current account.

Finally, in line with the findings of Aguiar and Gopinath (2007), we show that permanent shocks are the main source of output fluctuations in most EMEs. However, there are also countries in which trend shocks play a relatively marginal role. What is striking is that the fraction of income variation that can be attributed to permanent shocks is larger in countries in which the countercyclicality of the current account is driven by permanent shocks. This finding provides further support for our notion that the relative importance of domestic and international frictions varies across EMEs.

By and large, our results suggest that although EMEs exhibit common business cycle patterns, there is no common explanation for them. Macroeconomic dynamics may be driven by permanent shocks in one country, but they are mainly determined by transitory shocks in the other. Hence, we believe that it is hazardous to generally assert that *"the cycle is the trend"* in emerging markets.

The layout of this paper is as follows. Section 4.2 outlines the stochastic growth model of Aguiar and Gopinath (2007), slightly extended by a world interest rate shock. In Section 4.3, we introduce the empirical model and describe our identification scheme, which we validate using model generated data. In Section 4.4, we apply our methodology to identify permanent and transitory as well as global and country–specific components in macroeconomic variables for a large cross section of EMEs. Some concluding remarks appear in Section 4.5.

4.2 Theoretical Model

This section introduces the stochastic growth model, which we later use for the validation of our identification strategy. We present the model developed by Aguiar and Gopinath (2007) but augment their setup with a global shock in form of a world interest rate shock.

Consider a small open economy, which is inhabited by a unit measure of identical households. The theoretical economy features a homogeneous final good as well as an incomplete international capital market, such that there is only one risk–free non–contingent financial asset available for trade. Production technology manifests both a permanent and a transitory productivity process and is characterised by the following Cobb–Douglas function

$$Y_t = z_t K_t^{\alpha} (\Gamma_t l_t)^{1-\alpha},$$

where Y_t, K_t, l_t, and $\alpha \in (0,1)$ denote aggregate output, capital input, labour input, and the economy's capital share, respectively. Variables z_t and Γ_t capture two different exogenous technology processes. On the one hand, the economy is exposed to temporary changes in total factor productivity, which are governed by z_t. This stationary technology component follows an AR(1) process in logs:

$$z_t = z_{t-1}^{\rho_z} \exp(\epsilon_t^z), \quad \text{with} \quad \epsilon_t^z \sim \mathcal{N}(0, \sigma_z^2),$$

where $|\rho_z| < 1$ corresponds to the autoregressive coefficient and ϵ_t^z denotes the error term with variance σ_z^2. On the other hand, the economy is also subject to permanent changes in productivity. The non–stationary component in technology is represented by the labour–augmenting productivity process Γ_t, which equals the cumulative product of growth shocks g:

$$\Gamma_t = g_t \Gamma_{t-1} = \prod_{s=0}^{t} g_s, \quad \text{where} \quad g_t = \mu_g^{1-\rho_g} g_{t-1}^{\rho_g} \exp(\epsilon_t^g), \quad \text{with} \quad \epsilon_t^g \sim \mathcal{N}(0, \sigma_g^2).$$

The properties of the non–stationary technology process imply that (i) each realisation of g_s has a permanent impact on Γ_t, $\forall\ t \geq s$, and (ii) the steady state gross growth rate in the economy is given by μ_g. Parameter $|\rho_g| < 1$ determines the persistence of the permanent productivity process and ϵ_t^g describes the shock term which has a variance of σ_g^2.

The aggregate period resource constraint of the representative agent is

$$Y_t + \frac{B_{t+1}}{(1 + r_t)} = C_t + I_t + B_t,$$

where $\frac{1}{1+r_t}$, C_t, and I_t denote the price of foreign debt, household consumption, and aggregate investment, respectively. In addition, B_t describes the stock of foreign debt at date t carried over from period $t-1$, whereas B_{t+1} is the amount of newly issued international bonds with a maturity of one period.

In this framework the country's current account and net exports are equivalent. The current account equals the change in the foreign asset position, which is determined by the difference between savings and investment:

$$NX_t = Y_t - C_t - I_t = S_t - I_t = B_t - \frac{B_{t+1}}{(1+r_t)} = CA_t.$$

The evolution of the capital stock is subject to quadratic adjustment costs and described by the following law of motion:

$$K_{t+1} = (1-\delta)K_t + I_t - \frac{\phi}{2}\left(\frac{K_{t+1}}{K_t} - \mu_g\right)^2 K_t,$$

where ϕ determines the weight of adjustment costs and δ is the depreciation rate.

Per construction, Y_t, C_t, I_t, K_t, CA_t, and B_t exhibit a stochastic trend. In order to ensure a stationary system, we need to detrend these variables. Let x_t denote the stationary counterpart of X_t, which incorporates the stochastic trend. We can easily detrend our relevant variables through division by trend productivity in the previous period $t-1$:

$$x_t \equiv \frac{X_t}{\Gamma_{t-1}}.$$

As Schmitt-Grohé and Uribe (2003) point out, the equilibrium dynamics of SOE models with incomplete capital markets feature a random walk behaviour of international asset holdings. A convenient way to eliminate this unit root problem is to introduce a debt–elastic interest rate. In this vein, we assume that the interest rate on foreign debt borrowed at date t is determined by

$$1 + r_t = R_t^\star + \psi\left(\exp\left(b_{t+1} - b\right) - 1\right), \tag{4.1}$$

where $R_t^\star$ is the gross world interest rate, b is the steady state value of detrended debt, and $\psi > 0$ governs the debt elasticity of the interest rate.

We slightly extend the model by Aguiar and Gopinath (2007) and additionally allow for an exogenous stochastic interest rate shock. To be more precise, we assume that the world interest rate $R_t^\star$ follows an AR(1) process in logarithms:

$$\log(R_t^\star) = (1-\rho_R)\log(R^\star) + \rho_R \log(R_{t-1}^\star) + \epsilon_t^R, \quad \text{with} \quad \epsilon_t^R \sim \mathcal{N}(0, \sigma_R^2),$$

where $|\rho_R| < 1$, $R^\star$ is the steady state value of the gross world interest rate, and ϵ_t^R

denotes the interest rate shock term.

Preferences of the representative household are described by a standard Cobb–Douglas period utility function

$$u(C_t, l_t) = \frac{\left[C_t^{\gamma}(1 - l_t)^{1-\gamma}\right]^{1-\sigma}}{1 - \sigma},$$

where $\gamma \in (0, 1)$ is the consumption weight in utility and σ governs the curvature of period utility.

As a consequence, we can eventually state the stationary optimisation problem of the representative agent as

$$\begin{aligned} &\max_{\{c_\tau, l_\tau, k_{\tau+1}, b_{\tau+1}\}} \quad \mathrm{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} (\Gamma_{\tau-1}^{\gamma(1-\sigma)} u(c_\tau, l_\tau)) \\ \text{s.t.} \qquad & y_\tau + (1-\delta)k_\tau + \frac{g_\tau b_{\tau+1}}{(1+r_\tau)} = c_\tau + g_\tau k_{\tau+1} + \frac{\phi}{2}\left(g_\tau \frac{k_{\tau+1}}{k_\tau} - \mu_g\right)^2 k_\tau + b_\tau, \end{aligned}$$

for given k_t, b_t, and the transversality condition $\lim_{j\to\infty} \mathrm{E}_t \left(\frac{b_{t+1+j}}{\prod_{s=0}^{j}(1+r_s)}\right) = 0$, where parameter $\beta \in (0, 1)$ defines to the subjective discount factor. The solution to this maximisation problem as well as a summary of all model equations can be found in Appendix C.

4.3 Identification Approach

We now present our identification methodology. We begin with a description of our approach to identify permanent and transitory as well as global and country–specific shocks in macroeconomic time series. Subsequently, we apply our method to model generated data in order to scrutinise its performance.

4.3.1 Econometric Model

In the theoretical model described in Section 4.2, macroeconomic aggregates Y_t, C_t, I_t, K_t, CA_t, and B_t share a common stochastic trend. In other words, the model imposes a cointegrating relationship on these variables. Let $\mathbf{X}_t$ form a multivariate process consisting of any combination of variables in our model. If $\mathbf{X}_t$ comprises any of our non–stationary variables in the system, $\mathbf{X}_t$ is $I(1)$ (i.e. integrated of order one) and cointegrated with a cointegrating matrix $\boldsymbol{\beta}$, such that the linear combination $\boldsymbol{\beta}'\mathbf{X}_t$ is $I(0)$ (i.e integrated of order zero).[3] Accordingly, the process $\mathbf{X}_t$ has an error correction representation, which serves as the reduced form econometric model in our analysis.

The general form of a VECM is

$$\boldsymbol{\Gamma}(\mathbf{L})\Delta\mathbf{X}_t = \boldsymbol{\alpha}\boldsymbol{\beta}'\mathbf{X}_{t-1} + \boldsymbol{\epsilon}_t. \tag{4.2}$$

The cointegrating matrix $\boldsymbol{\beta}$ is of dimension $(n \times r)$, where n denotes the number of variables in the system and r is the cointegrating rank. $\boldsymbol{\epsilon}_t$ denotes the $(n \times 1)$ vector of reduced form shocks with mean zero and variance covariance matrix $\boldsymbol{\Sigma}$, and $\boldsymbol{\alpha}$ is the $(n \times r)$ loading matrix, which governs the adjustment to the long–run equilibrium. $\boldsymbol{\Gamma}(\mathbf{L}) = \mathbf{I}_n - \sum_{i=1}^{p-1} \boldsymbol{\Gamma}_i \mathbf{L}^i$ is an $(n \times n)$ lag polynomial, where p denotes the lag length of the associated VAR in levels.

4.3.2 Identification

Permanent versus Transitory Shocks

Let us first focus on the identification of permanent and transitory components in our cointegrated system. To this end, we apply the methodology described in Hoffmann (2001a).

We can use a multivariate version of the Beveridge and Nelson (1981) decomposition of our VECM in equation (4.2) to get

$$\mathbf{X}_t = \mathbf{C(1)} \sum_{l=0}^{t} \boldsymbol{\epsilon}_l + \mathbf{C}^{\star}(\mathbf{L})\boldsymbol{\epsilon}_t, \tag{4.3}$$

where $\mathbf{C(1)} \sum_{l=0}^{t} \boldsymbol{\epsilon}_l$ is the stochastic trend component and $\mathbf{C}^{\star}(\mathbf{L})\boldsymbol{\epsilon}_t$ is the transitory

[3] Note that we do not directly follow the original definition of cointegration by Engle and Granger (1987), which requires all components of $\mathbf{X}_t$ to be $I(1)$ in order to let $\mathbf{X}_t$ be $I(1)$. Instead, we rely on the broader definition by Johansen (1995) according to which the process $\mathbf{X}_t$ is $I(1)$ if the highest order of integration of any of its elements is one. This notion of cointegration allows unit vectors as potential cointegrating vectors.

component of $\mathbf{X}_t$, respectively. Since $\boldsymbol{\beta}'\mathbf{X}_t$ is $I(0)$ in our case, equation (4.3) implies that $\boldsymbol{\beta}'\mathbf{C}(\mathbf{1}) = 0$. Accordingly, the long–run multiplier matrix $\mathbf{C}(\mathbf{1}) = \sum_{j=1}^{\infty} \mathbf{C}_j$ has reduced rank $h < n$, such that there are $r = n - h$ cointegrating relationships and h common trends in the system. We can then write $\mathbf{C}(\mathbf{1}) = \mathbf{BA}'$, where $\mathbf{B}$ and $\mathbf{A}$ are $(n \times h)$ matrices of rank h. As a result, $\boldsymbol{\beta}'\mathbf{B}$ must be equal to zero, such that $\mathbf{B} = \boldsymbol{\beta}_{\perp}$, which is the orthogonal complement of $\boldsymbol{\beta}$. Moreover, we have $\mathbf{C}(\mathbf{1})\boldsymbol{\alpha} = \mathbf{0}$ implying that $\mathbf{A} = \boldsymbol{\alpha}_{\perp}$, which denotes the orthogonal complement of $\boldsymbol{\alpha}$.

According to Johansen (1995), the long–run multiplier matrix can be derived as

$$\mathbf{C}(\mathbf{1}) = \boldsymbol{\beta}_{\perp} \left(\boldsymbol{\alpha}_{\perp} \boldsymbol{\Gamma}(\mathbf{1}) \boldsymbol{\beta}_{\perp} \right)^{-1} \boldsymbol{\alpha}'_{\perp}.$$

Pre–multiplication of equation (4.2) by $\boldsymbol{\alpha}'_{\perp}$ eliminates all transitory dynamics in the model, which are captured in the error correction term $\boldsymbol{\beta}'\mathbf{X}_{t-1}$, and thereby yields the $(h \times 1)$ vector of permanent components:

$$\boldsymbol{\alpha}'_{\perp} \boldsymbol{\Gamma}(\mathbf{L}) \Delta \mathbf{X}_t = \boldsymbol{\alpha}'_{\perp} \boldsymbol{\epsilon}_t \equiv \boldsymbol{\pi}_t.$$

These permanent innovations correspond to the common trends in the system, such that we can easily rewrite equation (4.3) as

$$\mathbf{X}_t = \boldsymbol{\beta}_{\perp} \sum_{l=0}^{t} \boldsymbol{\pi}_l + C^{\star}(\mathbf{L}) \boldsymbol{\epsilon}_t,$$

which states the so–called Stock and Watson (1988) representation of cointegrated variables. Moreover, if we require permanent and transitory innovations to be orthogonal to one another, we can derive the vector of transitory shocks as

$$\boldsymbol{\tau}_t = \boldsymbol{\alpha}' \boldsymbol{\Sigma}^{-1} \boldsymbol{\epsilon}_t.$$

Next, we want permanent and transitory shocks to be orthogonal among themselves and to have unit variances. Since the orthogonal complement of $\boldsymbol{\alpha}$ is not uniquely defined, our isolation of permanent from transitory disturbances is not unique either. Hence, we follow the approach of Hoffmann (2013) and choose normalisation matrices $\mathbf{S}_\pi$ and $\mathbf{S}_\tau$, such that

$$\begin{aligned}\boldsymbol{\pi}_t &= \mathbf{S}_\pi' \boldsymbol{\alpha}_\perp' \boldsymbol{\epsilon}_t \\ \boldsymbol{\tau}_t &= \mathbf{S}_\tau' \boldsymbol{\alpha}' \boldsymbol{\Sigma}^{-1} \boldsymbol{\epsilon}_t.\end{aligned}$$

Unit variance of structural shocks requires that

$$\begin{aligned}Var(\boldsymbol{\pi}_t) &= \mathbf{S}_\pi' \boldsymbol{\alpha}_\perp' \boldsymbol{\Sigma} \boldsymbol{\alpha}_\perp \mathbf{S}_\pi = \mathbf{I}_h \\ Var(\boldsymbol{\tau}_t) &= \mathbf{S}_\tau' \boldsymbol{\alpha}' \boldsymbol{\Sigma}^{-1} \boldsymbol{\alpha} \mathbf{S}_\tau = \mathbf{I}_r.\end{aligned}$$

Accordingly, we have $\boldsymbol{\alpha}_\perp' \boldsymbol{\Sigma} \boldsymbol{\alpha}_\perp = \mathbf{S}_\pi^{-1'} \mathbf{S}_\pi^{-1}$ and $\boldsymbol{\alpha}' \boldsymbol{\Sigma}^{-1} \boldsymbol{\alpha} = \mathbf{S}_\tau^{-1'} \mathbf{S}_\tau^{-1}$. We can then use a Choleski decomposition of $\mathbf{S}_\pi^{-1'} \mathbf{S}_\pi^{-1}$ and $\mathbf{S}_\tau^{-1'} \mathbf{S}_\tau^{-1}$ to obtain the normalisation matrices $\mathbf{S}_\pi$ and $\mathbf{S}_\tau$.

Eventually, we can derive a matrix

$$\mathbf{P} = [\boldsymbol{\Sigma} \boldsymbol{\alpha}_\perp \mathbf{S}_\pi \quad \boldsymbol{\alpha} \mathbf{S}_\tau], \tag{4.4}$$

which maps our mutually orthogonal, unit variance permanent and transitory shocks $\boldsymbol{\Theta}_t = [\boldsymbol{\pi}_t \quad \boldsymbol{\tau}_t]'$ into reduced form disturbances $\boldsymbol{\epsilon}_t$:

$$\mathbf{P} \boldsymbol{\Theta}_t = \boldsymbol{\epsilon}_t.$$

Thus, we have completed the first stage of our identification strategy. Now recall that our DSGE model features three exogenous shocks: a permanent productivity shock, a temporary productivity shock, and a temporary world interest rate shock. It is therefore appropriate to focus on a trivariate system (i.e. $n = 3$) in order to identify these three structural shocks. Our identification method specified so far allows us to isolate the single common trend ($h = 1$) as well as the two transitory shocks ($r = n - h = 2$). Accordingly, we can immediately identify the permanent productivity shock. But how can we distinguish between technology and interest rate shocks among the transitory components?

Global versus Country–Specific Shocks

We follow Kano (2008) and Hoffmann (2013) and additionally impose short–run identifying restrictions in order to find the two temporary structural shocks. To this end, we consider the system $\mathbf{X}_t = \begin{bmatrix} r_t^\star & \frac{CA_t}{Y_t} & y_t \end{bmatrix}'$, where $r_t^\star \equiv \log(R_t^\star)$ and $y_t \equiv \log(Y_t)$. Since the current account and income exhibit the same stochastic trend, the ratio of these two variables is stationary as is the world interest rate $r_t^\star$. Consequently, our system is cointegrated with a trivial cointegrating matrix $\boldsymbol{\beta} = \left[\begin{smallmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \end{smallmatrix}\right]'$.

In our DSGE model, the world interest rate $r_t^\star$ follows an exogenous process and is thus only driven by shocks to itself. Therefore, we identify the transitory productivity shock as a country–specific, or idiosyncratic, shock, which has no contemporaneous impact on the world interest rate. In contrast, the world interest rate shock represents a global transitory shock and can have a contemporaneous impact on all variables in the system.

Matrix $\mathbf{P}$ shows the impact responses to permanent and transitory shocks. In particular, the (3×2) matrix $\boldsymbol{\alpha}\mathbf{S}_\tau$ determines the period zero responses to the two transitory shocks. Hence, our identification of global and country–specific temporary shocks imposes a restriction on $\boldsymbol{\alpha}\mathbf{S}_\tau$, such that

$$\boldsymbol{\alpha}\mathbf{S}_\tau = \begin{pmatrix} \star & 0 \\ \star & \star \\ \star & \star \end{pmatrix}.$$

How can we achieve this form of $\boldsymbol{\alpha}\mathbf{S}_\tau$? Note that our transitory shocks are already orthogonal to each other. Thus, if we apply a QR decomposition of the of the upper (2×2) part of $\boldsymbol{\alpha}\mathbf{S}_\tau$, we preserve the orthogonality of shocks. At the same time, however, it yields the desired zero entry in the upper right element of $\boldsymbol{\alpha}\mathbf{S}_\tau$.[4] As a result, we obtain an adjusted matrix $\widetilde{\mathbf{P}}$ that rotates our vector of structural shocks $\boldsymbol{\Theta}_t$, which comprises the permanent productivity shock π_t, the transitory global interest rate shock τ_t^g, and the transitory country–specific

[4]See Appendix C for details on how we use the QR decomposition to obtain our identifying restriction.

productivity shock τ_t^c, into the vector of reduced form innovations $\boldsymbol{\epsilon}_t$:

$$\widetilde{\mathbf{P}}\boldsymbol{\Theta}_t = \widetilde{\mathbf{P}}\begin{pmatrix}\pi_t \\ \tau_t^g \\ \tau_t^c\end{pmatrix} = \boldsymbol{\epsilon}_t.$$

Obviously, π_t, τ_t^g, and τ_t^c are the identified counterparts of g_t, $R_t^\star$, and z_t, respectively, in the DSGE model.[5]

4.3.3 Validation of the Identification Scheme

Before we take our identification method to the empirical data, we want to assess its strength. For this purpose, we use the DSGE model presented in Section 4.2 as data generating process and construct artificial time series. Subsequently, we apply our identification scheme to the generated data and check whether it can track the true underlying shocks.

Our approach is as follows. First, we log–linearise the stationary system of the DSGE model around its deterministic steady state and solve the model. Second, we assign parameter values to quantify the theoretical framework. For the sake of comparability, we follow Aguiar and Gopinath (2007) and choose their quarterly parametrisation for the Mexican economy.[6] Calibrated parameter values are summarised in Table 4.1. Third, we generate data for the stationary variables in the model from which we can easily recover the time series of the variables incorporating the stochastic trend.

Researchers in empirical macroeconomics usually do not know the pleasure of working with long time series data. For that reason, we produce data sets covering time spans of only 50 and 100 periods, respectively. This allows us to

[5]Note that our identification strategy does not rule out that the permanent shock has a contemporaneous effect on the world interest rate. While the world interest rate is only driven by transitory world interest rate shocks in the theoretical model, permanent shocks clearly might have an influence on the interest rate in the real data. In this sense, our identified permanent shock includes both global and idiosyncratic components. We will elaborate on this point in Section 4.4.

[6]These authors do not include an interest rate shock in their setup. To pin down the parameters governing the exogenous world interest rate process, we estimate an AR(1) model for the US gross real T–bill rate in logs. We use data from the first quarter of 1980 to the first quarter of 2003, which is the same time period analysed by Aguiar and Gopinath (2007).

Table 4.1: Calibration of the Theoretical Model

β	discount factor	0.98	z	mean of z process	1.00
γ	consumption weight in utility	0.36	b	steady state debt	0.10
σ	curvature of utility	2.00	ρ_z	persistence of z process	0.95
ϕ	weight of adjustment costs	4.00	ρ_g	persistence of g process	0.01
α	capital share	0.32	ρ_R	persistence of $R^\star$ process	0.63
δ	depreciation rate	0.05	σ_z	std. deviation of z process	0.48
ψ	debt elasticity	0.001	σ_g	std. deviation of g process	2.81
μ_g	steady state growth rate	1.0066	σ_R	std. deviation of $R^\star$ process	0.44

Notes: Standard deviations of structural shocks are expressed in percentages.

test how well the identification works in small samples. Finally, we repeat the data generating procedure 500 times to obtain a wide variety of data sets.

For each simulation, we estimate our VECM model from equation (4.2) specifying $\mathbf{X}_t = \begin{bmatrix} r_t^\star & \frac{CA_t}{Y_t} & y_t \end{bmatrix}'$ and including an unrestricted constant. In principle, we do not know how many lags we should use for estimation. Therefore, we choose lag lengths p varying from 1 to 4.[7] As we have discussed above, theory suggests a cointegrating matrix $\boldsymbol{\beta} = \left[\begin{smallmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \end{smallmatrix}\right]'$. Hence, we impose $\boldsymbol{\beta}$ and estimate our VECM using Least Squares (LS). Once we have estimated the model, we employ our methodology to identify the three structural shocks.

Correlation between True and Identified Shocks

Let us first look at the comovement of the true underlying shocks, which we have used to generate the data, and the corresponding shocks identified in the VECM. Table 4.2 displays summary statistics of the absolute correlation between the respective shock series. At this point, it is important to highlight that our structural innovations extracted from the VECM are unique only up to sign. Accordingly, we consider the absolute value of correlation coefficients, because we can only interpret their magnitudes but not their signs.

[7] Note that linearised DSGE models do not necessarily have a VAR representation. Studies by Fernández-Villaverde *et al.* (2007) and Ravenna (2007) discuss under which conditions this type of models can be written in VAR form. Indeed, our stochastic growth model does not have a finite order VAR representation for the multivariate process of output, current account, and the world interest rate. Ravenna (2007) highlights that estimating a finite order VAR approximation of the model may lead to biased results. Having said that, we believe that estimating a VECM which is not perfectly consistent with the underlying data generating process actually tightens the assessment of our identification method.

Table 4.2: Summary Statistics – Correlation between Identified and True Shocks

	$p = 1$			$p = 2$			$p = 3$			$p = 4$		
Panel A $T = 100$	π	τ^g	τ^c	π	τ^g	τ^c	π	τ^g	τ^c	π	τ^g	τ^c
Min	0.54	0.68	0.59	0.50	0.58	0.51	0.24	0.51	0.15	0.02	0.49	0.10
25% Quartile	0.91	0.95	0.84	0.89	0.92	0.84	0.85	0.90	0.83	0.82	0.87	0.81
Median	0.95	0.97	0.88	0.93	0.95	0.88	0.91	0.93	0.87	0.88	0.91	0.86
75% Quartile	0.97	0.99	0.90	0.96	0.97	0.90	0.94	0.95	0.90	0.92	0.94	0.89
Max	0.99	1.00	0.96	0.99	1.00	0.96	0.98	0.99	0.95	0.98	0.99	0.95
Mean	0.93	0.96	0.87	0.91	0.94	0.87	0.88	0.92	0.86	0.85	0.89	0.84
Std. Dev.	0.06	0.04	0.05	0.07	0.05	0.06	0.09	0.06	0.07	0.10	0.06	0.08
Panel B $T = 50$	π	τ^g	τ^c	π	τ^g	τ^c	π	τ^g	τ^c	π	τ^g	τ^c
Min	0.02	0.40	0.04	0.00	0.38	0.00	0.03	0.29	0.02	0.01	0.16	0.00
25% Quartile	0.81	0.89	0.80	0.76	0.84	0.76	0.70	0.79	0.71	0.61	0.73	0.65
Median	0.90	0.94	0.87	0.86	0.90	0.84	0.81	0.85	0.80	0.75	0.81	0.75
75% Quartile	0.96	0.97	0.91	0.92	0.94	0.88	0.87	0.90	0.85	0.84	0.86	0.81
Max	0.99	1.00	0.98	0.99	1.00	0.97	0.97	0.98	0.96	0.95	0.97	0.94
Mean	0.86	0.92	0.83	0.80	0.88	0.79	0.75	0.83	0.75	0.69	0.78	0.70
Std. Dev.	0.15	0.08	0.12	0.17	0.09	0.14	0.18	0.10	0.15	0.19	0.11	0.17

Notes: Summary statistics of the absolute value of the correlation between the true underlying shocks and the identified shocks. Results are based on 500 artificially generated samples covering a time span of 100 periods (Panel A) and 50 periods (Panel B), respectively. For each dataset, the VECM has been estimated for various lag lengths p, where p denotes the lag size of the associated VAR in levels.

The table reveals that our identification scheme does a remarkably good job. In general, we observe a very strong correlation between true and identified shocks. This is particularly true for permanent and global transitory disturbances. For instance, with $p = 1$ and for a sample size of 100 periods, the correlation between the true and identified permanent shocks is above 0.95 in half of our simulated samples. Regarding the global transitory shock, the median correlation is even 0.97. In contrast, comovement of idiosyncratic transitory shocks is somewhat weaker. Nonetheless, the correlation is 0.88 at the median, which still indicates a rather strong link.

Irrespective of the sample size, we observe that the comovement of shocks declines as the lag size increases. Moreover, our identification scheme works better if we have a large sample. Admittedly, this is not very surprising. It is interesting, however, that even if there are only 50 observations available for estimation, our method works considerably well. When we estimate the model for small samples using one lag, we get median correlations as high as 0.90, 0.94, and 0.87 for permanent, global transitory, and country–specific transitory shocks, respectively.[8]

The strong relationship between actual and predicted innovations is visualised in Figure 4.1. The graph plots the time series of true and identified shocks associated with the median correlation between the two. The results are obtained from estimations with one lag, based on samples with 100 observations. Recall that the variances of structural shocks retrieved from the VECM are normalised to one, while they are substantially less than one in the calibration of the DSGE model (see Table 4.1). This explains why we have different scales for the two series in the figure.

Identified Impulse Responses

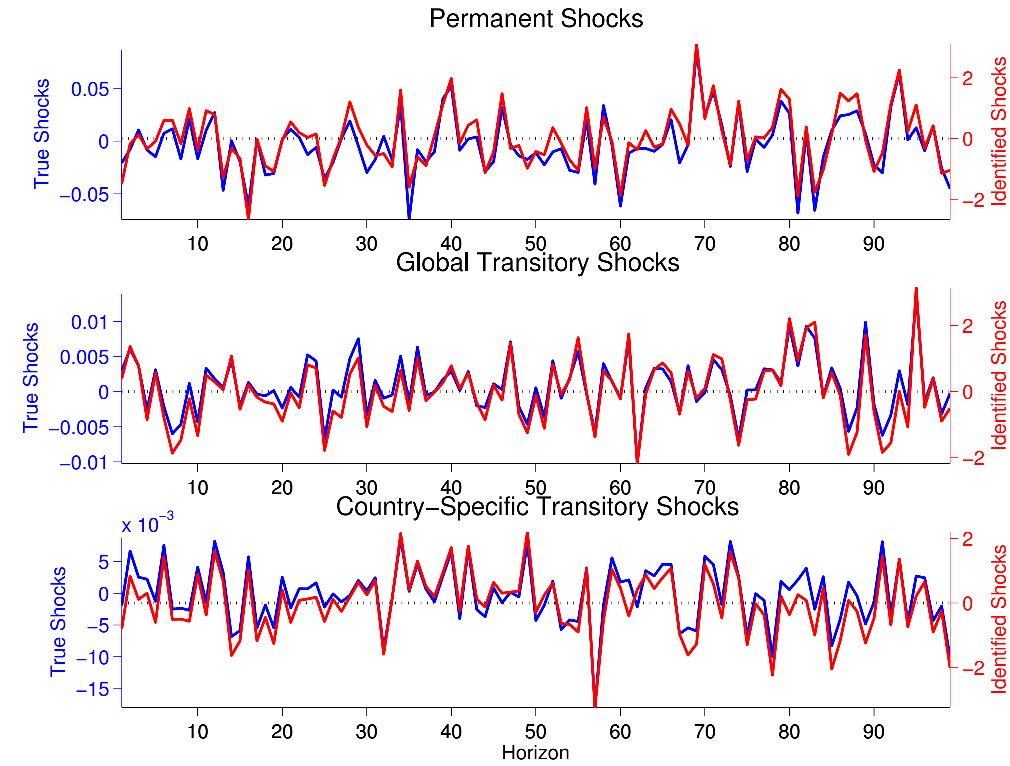
Our exercise has hitherto demonstrated how well our identification strategy extracts structural shocks from the data. Next, we want to analyse estimated impulse responses and compare them to their theoretical counterparts. Since our identified shocks are unique only up to sign, we basically do not know whether we are looking at a positive or negative structural shock. To this end, we simply interpret shocks as being positive if they cause a positive impact reaction of output.

Figure 4.2 shows estimated median impulse responses as well as their 90 percentage bounds of the current account to output ratio to our three shocks. Again, we consider estimation results for the VECM with one lag, based on samples covering 100 periods. For comparison, we also plot theoretical impulse responses to positive one percent shocks.

Theory predicts a fall (rise) in the current account to output ratio following a permanent (transitory) technology shock. Agents anticipate that a positive permanent shock not only raises present income but also leads to higher income in

[8]We have also investigated the asymptotic properties of our identification scheme (results are not reported here). That is, we have performed our exercise using very large samples with 100,000 observations. Our findings suggest that the correlation between true and identified shocks approaches to 1 as $T \rightarrow \infty$. This convergence is particularly strong for permanent and global transitory shocks.

Figure 4.1: Time Series of Identified and True Shocks

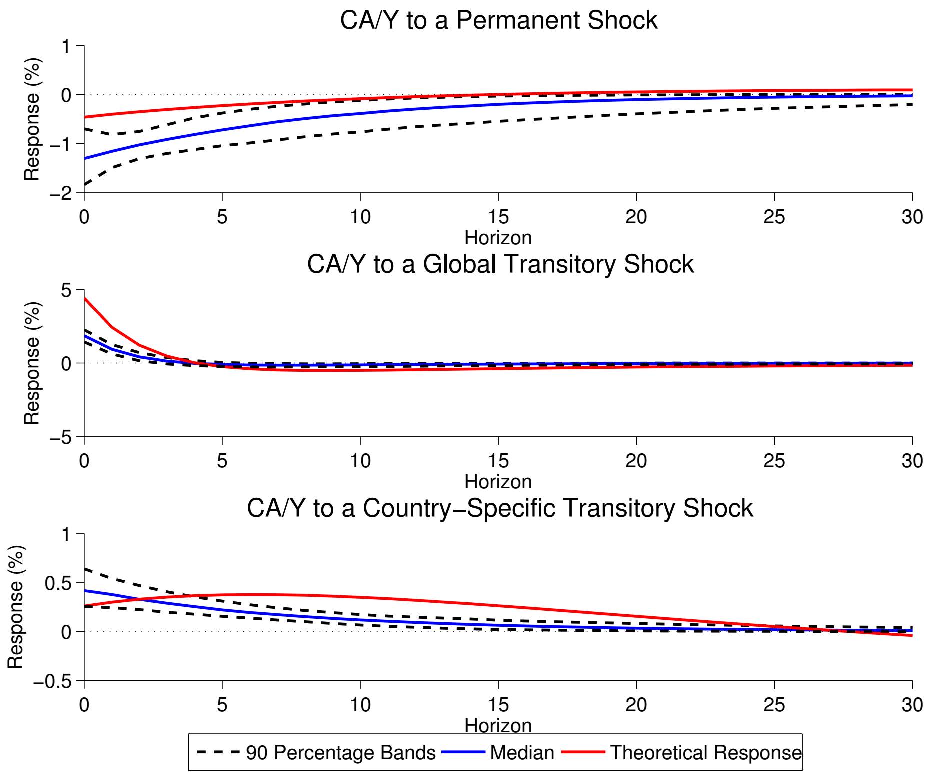


Notes: The figure shows the time series of shocks associated with the median correlation between true and identified innovations. The series of identified shocks is corrected for the sign of correlation. Results are based on the estimation of the VECM with lag length $p = 1$ and sample size $T = 100$.

the future. The desire for a smooth consumption path over time induces households to increase consumption more than the initial gain in income. Accordingly, the economy runs a current account deficit on impact in order to finance excess consumption. By contrast, the consumption smoothing rationale of agents creates an incentive to raise savings in response to a transitory shock. As a consequence, the increase in output outweighs the rise in consumption, such that the current account increases.

Likewise, $\frac{CA}{Y}$ increases after a positive world interest rate shock. A higher interest rate raises the price of today's consumption in terms of consumption tomorrow. This induces households to substitute present consumption for future consumption (substitution effect). Moreover, our calibration exercise implies that the small open economy has a negative net foreign asset position in the determ-

Figure 4.2: Identified and True Impulse Responses



Notes: Identified impulse responses versus model implied impulse responses of the current account to output ratio to the three structural shocks.

inistic equilibrium. Thus, the representative agent has an additional incentive to save more today in order to avoid higher interest payments on foreign debt (income effect). Income and substitution effect therefore work in the same direction. That is, a positive interest rate shock leads to an increase in domestic savings, or equivalently, a current account surplus.

Our figure suggests that estimated impulse responses are largely consistent with their theoretical counterparts from a qualitative perspective. On the one hand, the econometric model succeeds in predicting that the current account to income ratio increases after both types of transitory shocks, and falls after a permanent shock. On the other hand, it fails to reproduce the hump–shaped response of $\frac{CA}{Y}$ following an idiosyncratic transitory shock. However, this failure is not too bewildering. The VECM underlying the impulse responses in Figure 4.2 specifies only one lag. This implies that it can only generate impulse response functions that are geometrically decaying. Besides, our DSGE model describes the joint dynamic behaviour of a rich system of variables. It is therefore hard to expect our reduced form trivariate VECM to fully capture the dynamics of the variables. Indeed, this might more generally explain the differences between estimated and theoretical impulse responses.[9]

Overall, the exercise has illustrated that our identification strategy presents a very powerful tool to isolate both permanent and transitory as well as global and country–specific components in macroeconomic time series. We will now take our method to the empirical data in order to shed light on the role of different shocks in driving macroeconomic dynamics in EMEs.

4.4 Empirical Results

In the empirical part of our paper, we analyse the cointegrated VAR model from above using emerging market data. As we want to learn about the determinants of macroeconomic dynamics in EMEs in general, we estimate the model for a broad selection of countries.

4.4.1 Data

We employ quarterly data from the International Financial Statistics (IFS) of the International Monetary Fund (IMF) for 15 EMEs. It is generally arguable whether a country represents an emerging market or not because there exists no official definition. To this end, we study countries that are considered as being an emerging market according to at least one of the well–known lists of EMEs compiled by the IMF, Colombia University's Emerging Market Global Players (EMGP) project, Financial Times and Stock Exchange (FTSE), Morgan Stanley Capital International (MSCI), Standard and Poor's (S&P), and Dow Jones Indexes (DJI). Table 4.3 summarises country selection, data availability as well as EME classification. Unfortunately, time series on macroeconomic variables at business cycle frequen-

[9] A further reason for why our econometric model fails to exactly replicate theoretical responses is due to our VECM specification. As explained before, our DSGE model does not have a finite order VAR representation. Ravenna (2007) shows that VAR approximations of such models can lead to considerable discrepancies between estimated and theoretical impulse responses.

Table 4.3: List of Emerging Markets

Country	Data Range	Emerging Market Classification IMF	EMGP	FTSE	MSCI	S&P	DJI
Argentina (ARG)	1993Q1–2011Q4	⋆	⋆				
Brazil (BRA)	1995Q1–2011Q4	⋆	⋆	⋆	⋆	⋆	⋆
Czech Republic (CZE)	1994Q1–2011Q4			⋆	⋆	⋆	⋆
Hungary (HUN)	1995Q1–2011Q4	⋆	⋆	⋆	⋆	⋆	⋆
Indonesia (IDN)	1990Q1–2011Q4	⋆		⋆	⋆	⋆	⋆
Korea (KOR)	1975Q1–2011Q4		⋆		⋆		⋆
Malaysia (MYS)	1991Q1–2011Q4	⋆		⋆	⋆	⋆	⋆
Mexico (MEX)	1981Q1–2011Q4	⋆	⋆	⋆	⋆	⋆	⋆
Peru (PER)	1988Q1–2011Q4	⋆		⋆	⋆	⋆	⋆
Philippines (PHL)	1981Q1–2011Q4	⋆		⋆	⋆	⋆	⋆
Poland (POL)	1995Q1–2011Q4	⋆	⋆	⋆	⋆	⋆	⋆
Russia (RUS)	1995Q1–2011Q4	⋆	⋆	⋆	⋆	⋆	⋆
South Africa (ZAF)	1975Q1–2011Q4	⋆		⋆	⋆	⋆	⋆
Thailand (THA)	1993Q1–2011Q4	⋆		⋆	⋆	⋆	⋆
Turkey (TUR)	1987Q1–2011Q4	⋆	⋆	⋆	⋆	⋆	⋆

Notes: All data are taken from the IFS database. All countries under investigation can be defined as an emerging market according to at least one of the various and well–known classifications of EMEs established by the IMF, Colombia University's EMGP project, FTSE, MSCI, S&P, and DJI. The table reports the EME classifications as of 2013.

cies in EMEs are usually short or not available at all. This lack of data explains why our set of countries is rather limited and misses further economies that can potentially be categorised as an emerging market.

To estimate our model, we use real per capita data on GDP (Y) and net exports of goods and services (NX), which serves as a proxy for the current account (CA), and the real world interest rate ($R^{\star}$).[10] To construct real time series, we deflate output using the GDP deflator, whereas net exports deflated by the CPI.[11] Subsequently, we divide each series by population size to turn them into per capita terms. Unfortunately, the IFS data set only provides annual population data. To obtain quarterly population series, we interpret the reported figure as being the population size in quarter two and interpolate the missing observations using annual population growth rates. We use the real US T–bill rate as a proxy for

[10] Note that data availability motivates the choice of net exports instead of the current account in our empirical analysis. However, given the fact that the trade balance accounts for the lion's share of the current account in most EMEs, we are confident that NX represents a good proxy for CA. For this reason, we shall use these two expressions interchangeably in the rest of our paper.

[11] The Indonesian GDP deflator is not available for the whole sample period. For this country, we take the CPI to compute real GDP.

the world interest rate, which we determine by subtracting US CPI inflation from the quarterly US T–bill rate. The real per capita series of output and net exports are deseasonalised using the standard Census Bureau's X–12 ARIMA approach.

4.4.2 Cointegration Tests

Before we estimate our model, we first perform standard cointegration tests for each country. Table 4.4 displays the results of Johansen cointegration tests for the process $\mathbf{X}_t = \begin{bmatrix} r_t^\star & \frac{CA_t}{Y_t} & y_t \end{bmatrix}'$ based on the critical values provided by Osterwald-Lenum (1992). For each country, we include an unrestricted constant in the model and choose a lag length p as suggested by the standard information criteria AIC and BIC.[12]

Columns 3 and 6 of Table 4.4 report the trace and maximum eigenvalue statistic, respectively, for the null hypothesis of no cointegration ($r = 0$). There are only two countries (Malaysia and Peru) for which we are not able to reject the null of no cointegration at conventional significance levels in at least one of the two tests. Turning to the null hypothesis of $r = 1$, columns 4 and 7 of the table show that it is not to possible reject the null in most countries. In fact, the maximum eigenvalue test can only be rejected in 5 countries, namely the Czech Republic, the Philippines, Poland, Russia, and Turkey.

Accordingly, our findings indicate that there is no strong evidence of more than one cointegrating relationship in the majority of countries. This is a contradiction to our theoretical model, which suggests a cointegrating rank of two. Yet we have to be careful in interpreting our results. A well–known drawback of these cointegration tests is that they have low power. In other words, the probability of not rejecting the null when it is wrong is very high. Hence, in some cases we might spuriously infer that there is only one cointegrating vector. In the following analysis, we will therefore presume that there is a single common trend in the data, i.e. $r = 2$. Furthermore, as in Section 4.3, we impose the cointegrating matrix

[12]For some countries, the BIC suggests only one lag. In this case, we set p according to the AIC in order to better capture the dynamics in the variables. Otherwise, our decision for the AIC or BIC is based on diagnostic checks on model adequacy (e.g. white noise properties of residuals). Nevertheless, inference on our cointegration tests appears to be fairly insensitive regarding the criterion used to determine p.

Table 4.4: Johansen's Cointegration Test

	p	λ_{trace}			λ_{max}		
		$r = 0$	$r = 1$	$r = 2$	$r = 0$	$r = 1$	$r = 2$
ARG	5	31.46**	8.43	0.39	23.03*	8.04	0.39
BRA	5	27.39*	8.64	0.17	18.75*	8.48	0.17
CZE	1	66.08***	24.59***	1.60	41.48***	23.00***	1.60
HUN	2	54.37***	8.90	2.83*	45.47***	6.07	2.83*
IDN	1	54.34***	12.57	1.01	41.77***	11.56	1.01
KOR	4	32.46**	14.96*	5.65**	17.50	9.31	5.65**
MYS	3	25.23	10.10	2.86*	15.12	7.24	2.86*
MEX	3	32.19**	6.03	0.14	26.16***	5.89	0.14
PER	5	20.57	6.74	2.60	13.82	4.14	2.60
PHL	1	62.81***	13.99*	0.12	48.81***	13.87*	0.12
POL	1	47.87***	15.42**	0.08	32.45***	15.34*	0.08
RUS	2	64.24***	14.73*	0.30	49.51***	14.43**	0.30
ZAF	3	27.05*	11.85	0.05	15.20	11.80	0.05
THA	1	58.19***	11.53	1.67	46.66***	9.87	1.67
TUR	2	67.12***	16.60**	0.18	50.52***	16.42**	0.18

Notes: Critical values are taken from Osterwald-Lenum (1992). *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. All models incorporate an unrestricted constant. Selection of lag length is based on the application of the standard information criteria AIC and/or BIC.

$\boldsymbol{\beta} = \left[\begin{smallmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \end{smallmatrix}\right]'$ as implied by the DSGE model.[13]

4.4.3 Global and Country–Specific Components

In Section 4.3, we have illustrated that our identification scheme succeeds in retrieving global and country–specific components from artificial data. Admittedly, the fact that we knew the underlying data generating process helped us to impose appropriate identifying restrictions on matrix $\mathbf{P}$ in equation (4.4). Unfortunately, with the empirical data we cannot be a priori sure about the quality of this strategy. To this end, we will now check how global and country–specific our identified shocks in the data really are.

Our approach builds on Hoffmann (2001b) and Hoffmann (2003). Given that we estimate the model for each country separately, we can assess the strength of our method by inspecting the bilateral correlation of shocks. Clearly, our

[13]In Appendix C, we test the restrictions on the cointegrating space predicted by the DSGE model. As a matter of fact, we reject the theoretically imposed cointegrating matrix in the majority of countries. Therefore, we also perform our empirical exercise based on an estimated cointegrating matrix $\boldsymbol{\beta}$. Yet the main empirical results in this paper seem to be robust to whether we estimate or impose $\boldsymbol{\beta}$.

identification should yield country–specific shocks which are rather uncorrelated across countries. By contrast, identified global shocks ought to be substantially related.

Tables 4.5 and 4.6 show pairwise correlations of global and country–specific innovations, respectively. Indeed, we observe a much stronger link between global shocks than between idiosyncratic shocks. The average correlation of global disturbances is significant at the 1% level for all countries. Regarding country–specific shocks, mean correlations are very low and insignificant at conventional levels for all but three countries. Although the average correlation of idiosyncratic shocks is significantly different from zero for Indonesia, Peru, and Poland, the coefficient is still rather small. Furthermore, all pairwise correlations between global shocks are fairly high and positive, whereas they are generally low and have mixed signs for country–specific shocks. As a consequence, our theory guided identification of global and country–specific disturbances seems to work well not only with artificial data but also with empirical data.

In addition, Table 4.7 presents the bilateral correlations of permanent shocks. Note that our identification strategy isolates the single permanent shock, but does not specify whether it is driven by global or idiosyncratic factors. In our exercise with artificial data above, this was not our concern since we knew that the common trend was driven by country–specific, non–stationary disturbances in technology. In the real data, however, our identified permanent shock may feature both global and idiosyncratic components. Indeed, the table shows that the comovement of permanent shocks across countries is not negligible. For all countries, except Korea and Poland, we find that average cross–correlations are significantly different from zero at least at the 10% level. Mean correlations range from −0.10 for Argentina to 0.27 for South Africa and Thailand. This finding might suggest that permanent shocks have global components but are mainly determined by idiosyncratic factors.

Table 4.5: Cross–Country Correlations of Global Shocks

	ARG	BRA	CZE	HUN	IDN	KOR	MYS	MEX	PER	PHL	POL	RUS	ZAF	THA	TUR
ARG	1.00														
BRA	0.62	1.00													
CZE	0.61	0.64	1.00												
HUN	0.62	0.67	0.91	1.00											
IDN	0.54	0.61	0.90	0.84	1.00										
KOR	0.54	0.48	0.64	0.69	0.54	1.00									
MYS	0.67	0.78	0.83	0.84	0.82	0.62	1.00								
MEX	0.59	0.70	0.82	0.82	0.74	0.67	0.91	1.00							
PER	0.55	0.41	0.49	0.49	0.46	0.29	0.56	0.48	1.00						
PHL	0.55	0.63	0.89	0.85	0.86	0.58	0.79	0.76	0.49	1.00					
POL	0.63	0.67	0.97	0.94	0.91	0.67	0.84	0.83	0.51	0.93	1.00				
RUS	0.58	0.67	0.88	0.91	0.85	0.54	0.83	0.81	0.50	0.84	0.89	1.00			
ZAF	0.62	0.76	0.86	0.82	0.80	0.65	0.94	0.92	0.48	0.79	0.85	0.80	1.00		
THA	0.52	0.64	0.88	0.84	0.86	0.48	0.83	0.77	0.54	0.85	0.88	0.89	0.82	1.00	
TUR	0.66	0.70	0.93	0.98	0.89	0.71	0.87	0.85	0.53	0.90	0.96	0.94	0.86	0.89	1.00
Mean	**0.59**	**0.64**	**0.80**	**0.80**	**0.76**	**0.58**	**0.79**	**0.76**	**0.48**	**0.77**	**0.82**	**0.78**	**0.78**	**0.76**	**0.83**
Std. Error	0.01	0.03	0.04	0.04	0.04	0.03	0.03	0.03	0.02	0.04	0.04	0.04	0.03	0.04	0.04

Notes: The table shows the correlation of identified shocks across countries for the time period from 1992Q2 to 2011Q4. Cross–sectional means which are significant at 1%, 5%, and 10% are highlighted bold, italics, and underlined, respectively. The mean correlation for country i is $\bar{\rho}_i = \frac{1}{14}\sum_{j=1,j\neq i}^{15} \rho_{i,j}$ and the cross–sectional sample variance of correlation coefficients is $\sigma_i^2 = \frac{1}{13}\sum_{j=1,j\neq i}^{15}(\rho_{i,j} - \bar{\rho}_i)^2$.

Table 4.6: Cross–Country Correlations of Country–Specific Shocks

	ARG	BRA	CZE	HUN	IDN	KOR	MYS	MEX	PER	PHL	POL	RUS	ZAF	THA	TUR
ARG	1.00														
BRA	0.29	1.00													
CZE	−0.09	−0.04	1.00												
HUN	−0.07	−0.32	0.07	1.00											
IDN	0.09	0.20	0.02	0.01	1.00										
KOR	−0.04	0.06	0.10	0.19	0.09	1.00									
MYS	−0.19	0.05	0.18	−0.05	−0.02	−0.08	1.00								
MEX	−0.04	−0.19	0.14	0.25	−0.09	0.17	0.25	1.00							
PER	0.37	0.18	−0.07	0.09	0.09	0.01	0.16	0.10	1.00						
PHL	0.25	−0.10	−0.10	−0.22	0.12	−0.18	−0.05	−0.17	0.10	1.00					
POL	0.10	0.24	0.18	0.09	0.14	0.20	−0.15	0.04	0.38	−0.16	1.00				
RUS	0.02	0.02	0.13	−0.12	0.19	−0.20	0.23	−0.07	0.09	0.34	0.08	1.00			
ZAF	−0.05	0.16	−0.08	−0.12	0.05	−0.13	−0.23	−0.08	−0.01	−0.02	0.03	−0.04	1.00		
THA	0.05	0.27	0.18	−0.24	0.11	0.16	−0.05	−0.24	−0.04	0.03	0.05	−0.05	0.03	1.00	
TUR	0.05	0.41	−0.05	−0.09	0.15	0.24	−0.14	−0.13	0.10	−0.08	0.37	−0.20	0.14	0.09	1.00
Mean	0.05	0.09	0.04	−0.04	**0.08**	0.04	−0.01	−0.01	**0.11**	−0.02	**0.11**	0.03	−0.02	0.02	0.06
Std. Error	0.04	0.05	0.03	0.04	0.02	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.04	0.05

Notes: The table shows the correlation of identified shocks across countries for the time period from 1992Q2 to 2011Q4. Cross–sectional means which are significant at 1%, 5%, and 10% are highlighted bold, italics, and underlined, respectively. The mean correlation for country i is $\bar{\rho}_i = \frac{1}{14}\sum_{j=1,j\neq i}^{15} \rho_{i,j}$ and the cross–sectional sample variance of correlation coefficients is $\sigma_i^2 = \frac{1}{13}\sum_{j=1,j\neq i}^{15}(\rho_{i,j} - \bar{\rho}_i)^2$.

Table 4.7: Cross–Country Correlations of Permanent Shocks

	ARG	BRA	CZE	HUN	IDN	KOR	MYS	MEX	PER	PHL	POL	RUS	ZAF	THA	TUR
ARG	1.00														
BRA	−0.27	1.00													
CZE	0.00	0.30	1.00												
HUN	0.08	0.20	0.18	1.00											
IDN	−0.20	0.29	0.27	−0.14	1.00										
KOR	0.16	−0.12	0.00	−0.04	−0.18	1.00									
MYS	−0.15	0.44	0.26	−0.03	0.44	0.34	1.00								
MEX	−0.19	0.32	0.45	0.18	0.30	−0.21	0.31	1.00							
PER	−0.40	0.47	0.08	−0.06	0.34	−0.46	0.26	0.33	1.00						
PHL	−0.03	0.24	0.14	0.00	0.21	−0.20	0.24	0.32	0.32	1.00					
POL	0.04	−0.06	−0.11	0.07	−0.06	−0.14	−0.11	−0.11	0.05	0.00	1.00				
RUS	0.17	0.00	−0.06	0.25	−0.09	0.04	0.18	0.11	0.07	0.00	0.16	1.00			
ZAF	−0.35	0.61	0.42	0.16	0.49	−0.49	0.39	0.64	0.67	0.42	−0.07	0.13	1.00		
THA	−0.10	0.42	0.44	0.11	0.46	−0.05	0.52	0.38	0.48	0.29	−0.11	0.20	0.55	1.00	
TUR	−0.21	0.11	0.26	0.24	0.20	0.02	0.23	0.35	0.07	−0.02	0.07	0.20	0.19	0.25	1.00
Mean	*−0.10*	**0.21**	**0.19**	**0.09**	*0.16*	−0.10	**0.24**	**0.23**	<u>0.16</u>	**0.14**	−0.03	**0.10**	**0.27**	**0.27**	**0.14**
Std. Error	0.05	0.07	0.05	0.03	0.07	0.06	0.06	0.07	0.09	0.05	0.02	0.03	0.10	0.06	0.04

Notes: The table shows the correlation of identified shocks across countries for the time period from 1992Q2 to 2011Q4. Cross–sectional means which are significant at 1%, 5%, and 10% are highlighted bold, italics, and underlined, respectively. The mean correlation for country i is $\bar{\rho}_i = \frac{1}{14}\sum_{j=1,j\neq i}^{15}\rho_{i,j}$ and the cross–sectional sample variance of correlation coefficients is $\sigma_i^2 = \frac{1}{13}\sum_{j=1,j\neq i}^{15}(\rho_{i,j} - \bar{\rho}_i)^2$.

4.4.4 Impulse Responses

Next, we evaluate the reaction of capital flows and income to the three structural shocks. Table 4.8 summarises the impact responses of the current account to GDP ratio and output. As mentioned before, our identification of shocks is unique only up to sign. Hence, we again interpret shocks as being positive if they lead to a period zero increase in output and accordingly adjust the sign of the $\frac{CA}{Y}$ responses. Complete impulse responses of the current account to output ratio and income for each country are presented in Appendix C.

Before we indulge in the discussion of our results, it is worthwhile to first take a look at the comovement of capital flows and income. Column two of the table reports the sample correlation between the current account to GDP ratio and the HP cycle of the log of output. The correlation is not only negative throughout the sample, except for Russia, but also indicates a noticeable negative relationship between the two variables in most countries. This observation just underpins the stylised fact of a countercyclical current account to output ratio in EMEs.

But this raises the question of what drives this countercyclicality. To shed more light on this phenomenon, we examine the reaction of the current account to various shocks. As is evident from columns 3 to 5 of the table, there seems to be no common pattern in the impact responses of $\frac{CA}{Y}$. What is striking is that in all countries, except Turkey, the countercyclicality of the current account can be explained by the response to either permanent or country–specific transitory shocks, but never by both. In 7 countries, namely the Czech Republic, Hungary, Indonesia, Korea, Malaysia, Mexico, and Thailand, the negative correlation between the current account to output ratio and GDP arises from permanent shocks. By contrast, temporary shocks account for the countercyclicality of $\frac{CA}{Y}$ in 7 countries: Argentina, Brazil, Peru, the Philippines, Poland, Russia, and South Africa. Interestingly, all three types of shocks cause a capital inflow in Turkey, whereof country–specific innovations lead to the most pronounced response.

This is one of the main findings of our empirical exercise. The two distinct patterns in the reaction of the current account to output ratio is visualised in Figure 4.3. On the one hand, there are countries located in the north–west quadrant of

Table 4.8: Impact Impulse Responses

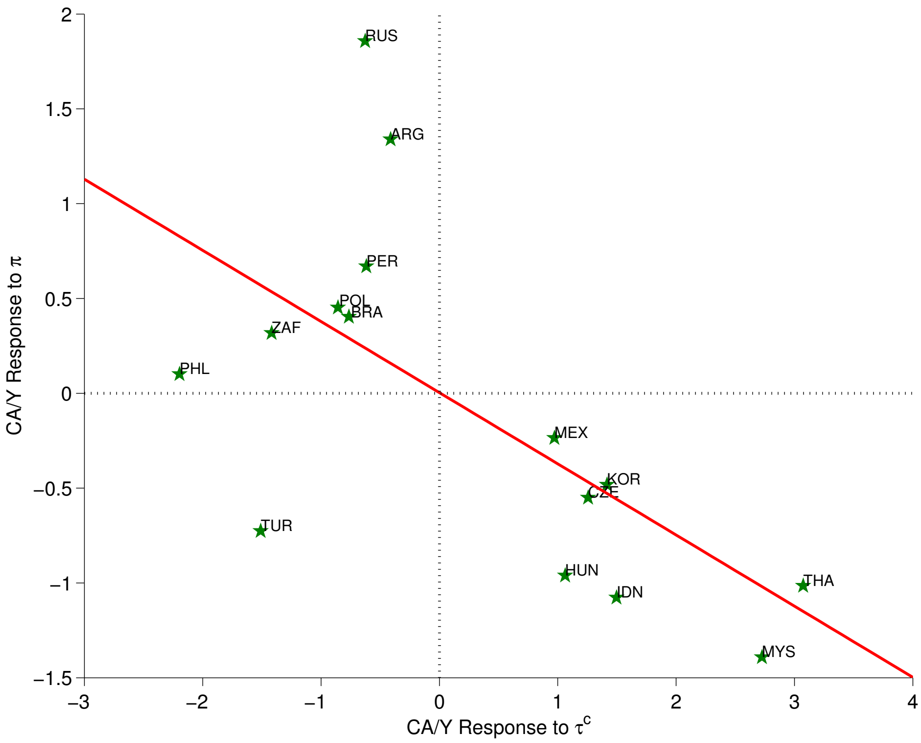
	Sample Correlation between $\frac{CA}{Y}$ and y	$\frac{CA}{Y}$			y		
		π	τ^g	τ^c	π	τ^g	τ^c
ARG	−0.50	1.34	−0.76	−0.41	0.14	0.13	2.05
BRA	−0.08	0.40	0.47	−0.77	0.88	0.02	0.66
CZE	−0.10	−0.55	−0.13	1.26	1.57	0.01	0.44
HUN	−0.27	−0.96	−0.06	1.06	0.80	0.16	0.37
IDN	−0.08	−1.08	−0.35	1.50	1.69	0.41	1.84
KOR	−0.32	−0.48	−1.05	1.42	1.09	1.24	0.62
MYS	−0.25	−1.39	−0.90	2.73	1.59	0.20	0.05
MEX	−0.35	−0.24	−0.11	0.97	1.40	0.22	0.09
PER	−0.33	0.67	0.99	−0.62	0.52	0.82	2.29
PHL	−0.33	0.10	0.40	−2.20	1.76	0.61	0.21
POL	−0.50	0.45	−0.11	−0.86	1.06	0.02	0.62
RUS	0.05	1.86	0.32	−0.63	1.10	0.43	1.57
ZAF	−0.39	0.32	0.05	−1.42	0.63	0.43	0.16
THA	−0.46	−1.01	−0.70	3.07	2.08	0.62	0.65
TUR	−0.55	−0.73	−0.33	−1.51	2.84	0.16	0.10
Median	−0.33	−0.24	−0.11	−0.41	1.10	0.22	0.62
Mean	−0.30	−0.09	−0.15	0.24	1.28	0.37	0.78
Std. Dev.	0.18	0.93	0.56	1.59	0.68	0.34	0.77

Notes: The table shows the impact responses of the current account to GDP ratio and income to the three structural shocks. Responses have been multiplied by 100 and corrected for the sign of the impact responses of output. The sample correlation between $\frac{CA}{Y}$ and y corresponds to the correlation between the current account to GDP ratio and the cyclical component of the log of output, which has been derived using the HP filter with smoothing parameter 1,600.

the diagram, which exhibit an increase in $\frac{CA}{Y}$ after a permanent shock and a fall in $\frac{CA}{Y}$ after a country–specific transitory disturbance. On the other hand, there are EMEs located in the south–east quadrant of the diagram in which permanent shocks lead to a capital inflow, whereas country–specific transitory disturbances cause a capital outflow. In addition, the graph suggests that there is a negative link between the impact responses to the two shocks. The stronger the reaction of $\frac{CA}{Y}$ to a permanent shock, the stronger is its response to an idiosyncratic transitory disturbance, but in the opposite direction. Indeed, the correlation coefficient between the responses is −0.64 and significant at the 5% level.

As a consequence, although EMEs share the empirical regularity of strongly countercyclical current accounts, we do not find a common explanation for it. This result is quite interesting in light of the conflicting arguments of two prominent

Figure 4.3: Impact Responses of $\frac{CA}{Y}$



Notes: The scatter plot displays the impact impulse response of the current account to output ratio to a permanent shock (vertical axes) and a country–specific transitory shock (horizontal axis). The solid line represents the OLS regression line.

contributions to the literature on macroeconomic dynamics in EMEs. On the one hand, Aguiar and Gopinath (2007) state that EMEs exhibit a countercyclical trade balance and are more likely to suffer from sudden stops in capital inflows, because they are more prone to permanent shocks. Our findings only partly support their story since the impulse response of $\frac{CA}{Y}$ to permanent shocks is not negative in all countries. Nevertheless, we also observe that permanent shocks account for the countercyclicality of the current account in Mexico, which is exactly the country they analyse in their study. On the other hand, García-Cicco *et al.* (2010) argue that the Argentine economy is predominantly hit by temporary shocks, whereas permanent shocks play virtually no role. In this vein, our analysis complements their findings since we detect that it is transitory and not permanent disturbances that explain the countercyclicality of the current account in Argentina.

So far, our discussion of impulse responses has focussed on permanent and idiosyncratic transitory shocks. Let us now consider how global shocks affect the current account. Column 4 of Table 4.8 shows that the current account to output ratio falls after a transitory global shock in two thirds of EMEs. At a first glance, this result seems to be inconsistent with an important implication of the intertemporal approach to the current account. The intertemporal approach predicts that global output shocks should not affect the current account, but translate into changes in the world interest rate (see Obstfeld and Rogoff (1995)). Yet since we look at the ratio of the current account to output, the negative negative sign of the response partly reflects the increase in output after a global shock. More interesting, however, one third of the countries exhibit a positive response of $\frac{CA}{Y}$. This implies that the increase in the current account actually outweighs the rise in income following a global shock, which is a palpable contradiction to the theory of the intertemporal approach.

Turning to the impulse responses of output in columns 6 to 8 of the table, we observe that the reaction of income following a permanent shock is generally more pronounced than after transitory shocks. In only four countries (Argentina, Indonesia, Peru, and Russia), country–specific temporary shocks lead to a stronger change in output than permanent innovations. Moreover, impact responses to global disturbances appear to be fairly modest. The only exception in this respect is Korea, where the period zero response of output to global shocks exceeds the one to permanent and idiosyncratic shocks.

4.4.5 Explaining Current Account Dynamics

Our analysis in the previous subsection has revealed interesting patterns in the impulse responses of the current account. We have shown that the negative correlation of the current account and output in EMEs is driven by the response of the current account to either permanent or transitory country–specific shocks, but virtually never both. In this subsection, we want to shed more light on these particular dynamics of the current account and discuss potential explanations for them.

Permanent Shocks

Reconsider the general equilibrium model of Section 4.2. As illustrated in Section 4.3, our DSGE model, and basically any standard model of the intertemporal approach to the current account, predicts a decline in the current account after a permanent shock. Yet our empirical results suggest that trend shocks lead to an increase in $\frac{CA}{Y}$ in about half of the countries. So how can we explain this apparent anomaly within the framework of the intertemporal model?

In principle, our empirical impulse responses are not necessarily at odds with their theoretical counterpart. Our calibration of the DSGE model virtually precludes persistence of the non–stationary productivity process ($\rho_g = 0.01$). As a matter of fact, we can easily generate a positive conditional correlation between $\frac{CA}{Y}$ and output after a permanent shock by simply raising ρ_g.[14] The reason for this can be explained by the income effect on labour supply implied by CRRA preferences. The income effect induces agents to work less and enjoy more leisure after a positive shock, whereas the substitution effect creates an incentive to work more. Accordingly, if a very persistent non–stationary technology shock occurs, the income effect predominates the substitution effect, such that labour input declines. If the fall in labour outweighs the increase in productivity, output and the current account fall initially, which implies a positive conditional correlation between these two variables. However, if we take a look at the empirical impulse responses of output, we do not observe this particular pattern in any country. This finding suggests that there are no strong income effects in EMEs.[15] Hence, we cannot explain the observed positive reaction of the current account after trend shocks by a high persistence of this type of shocks.

Another possible explanation for the positive impact response of $\frac{CA}{Y}$ to a permanent disturbance would be an overshooting of output. Imagine that the immediate reaction of income following a permanent shock is larger than its long–run

[14] In Appendix C, we present impulse responses of the current account to output ratio and income to a permanent shock in the DSGE model for different values of ρ_g.

[15] Many researchers use so–called GHH preferences, named after Greenwood, Hercowitz and Huffman (1988), instead of CRRA utility, because they produce more plausible labour dynamics and allow the model to replicate certain business cycle properties in emerging markets (see Neumeyer and Perri (2005) and Boz *et al.* (2011)). In fact, a key difference between CRRA and GHH preferences is that the latter do not feature any income effects on labour supply.

change. That is, output overshoots in the short–run and converges to its new long–run level from above. In that scenario, a positive trend shock induces households to save rather than borrow at international capital markets. As a result, a permanent shock leads to an increase in both output and the current account on impact. If we look at the estimated impulse responses of income to a permanent disturbance, we only find such an overshooting pattern for Turkey. But Turkey's current account actually falls after a permanent shock. Accordingly, an overshooting behaviour of output cannot be the explanation for the empirical positive conditional correlation between $\frac{CA}{Y}$ and income, either.

That said, our findings suggest a puzzle. Conditional on a positive impact response of output, our dynamic general equilibrium model cannot explain the positive reaction of the current account after a trend shock. In light of this, one needs to think about potential missing ingredients in the intertemporal model that help to resolve this puzzle.

Transitory Shocks

In Section 4.3, we have demonstrated that the stochastic growth model predicts an increase in the current account in response to a stationary technology shock. However, the current account actually drops after an idiosyncratic temporary shock in roughly 50 percent of our countries.

We now show how we can augment the DSGE model with financial frictions in a straightforward way, such that it succeeds in reproducing this particular reaction of the current account. In a prominent article, Neumeyer and Perri (2005) stress the virtue of decomposing the real interest rate into a world interest rate and a country risk component. Therefore, we extend the model by a country risk premium on the interest rate as an ad hoc form of financial market distortions. That is, we adjust our interest rate rule in equation (4.1) to

$$1 + r_t = R_t^\star + \psi \left(\exp \left(b_{t+1} - b \right) - 1 \right) + S_t,$$

where S_t is the country spread, which captures the country's risk of default. We follow Neumeyer and Perri (2005) and assume that the risk of default depends on country fundamentals, such that shocks to the economy directly affect the spread term. For the sake of simplicity, we specify the country spread as a decreasing function of expected future stationary technology z_{t+1}:

$$S_t = -\eta \left(\exp \left(\mathrm{E}_t \left[z_{t+1} \right] - z \right) - 1 \right),$$

where parameter $\eta \geq 0$ determines the sensitivity of the interest rate with respect to changes in the stationary TFP component. The functional form of S_t reflects the idea that the country risk and therefore the country premium is low (high) if prospects about future economic activity are good (bad). Accordingly, the interest rate does no longer equal the world interest rate but depends on domestic economic conditions. That is why we can think of the modified interest rate rule as featuring a reduced form financial friction.[16]

The inclusion of a country spread changes the propagation of a transitory TFP shock.[17] A positive temporary technology shock reduces the country risk and therefore lowers the spread. The associated decline in the interest rate induces households to increase consumption and investment by more than without a change in the cost of borrowing. Accordingly, the country spread introduces an amplification mechanism in the model. As a matter of fact, the more severe the extent of the financial friction, i.e. the larger the size of parameter η, the stronger is this amplification effect. If the drop in the interest rate is large enough, domestic absorption exceeds output, such that the economy runs a current account deficit. Accordingly, the introduction of reduced form financial frictions can indeed help to explain the negative response of $\frac{CA}{Y}$ to country–specific transitory shocks.

Domestic versus International Frictions

We have elaborated in how far the intertemporal model can account for the empirical impulse responses of the current account. In light of our discussion, we now try to provide a coherent explanation for the observed discrepancies in the

[16]Note that this specification also implies that the extended model nests the baseline setup from Section 4.2. More precisely, if we set $\eta = 0$, there is no country premium and the interest rate rule is again given by equation (4.1).

[17]Impulse responses of $\frac{CA}{Y}$ and y to a temporary TFP shock in the extended model are presented in Appendix C.

current account dynamics.

We can imagine that EMEs are characterised by various forms of market frictions, which have an impact on the behaviour of economic agents. Depending on how and where market distortions appear in the economy, they can lead to very different macroeconomic dynamics.

On the one hand, there is the story of García-Cicco *et al.* (2010) and Chang and Férnandez (2013). They argue that imperfections at international capital markets rather than trend shocks are responsible for the dynamics in emerging markets. As we have shown above, the introduction of country spreads in the intertemporal model indeed helps to reproduce a negative response of the current account to transitory shocks. This suggests that countries in which transitory shocks drive the countercyclicality of the current account are particularly characterised by *international frictions*. Nevertheless, this interpretation does not resolve the puzzle of why there is a positive conditional correlation between the current account and income after a permanent shock in these countries.

On the other hand, Aguiar and Gopinath (2007) advocate the theory that the negative correlation between the current account and income arises from the response of the current account to permanent shocks. Although their model does not feature an explicit form of financial frictions, we can imagine that market distortions manifest themselves in the non–stationary productivity component. That is, the Aguiar and Gopinath setup does not incorporate frictions in international borrowing and lending but the permanent shock introduces a domestic efficiency wedge in the model (see Chari *et al.* (2007)). Thus, we can think of EMEs in which trend shocks drive the countercyclicality of the current account as being mainly characterised by *domestic frictions*. Moreover, since these countries exhibit a capital outflow after an idiosyncratic transitory shock, international frictions seem to be less pronounced.

This suggests that the relative importance of domestic and international frictions varies across EMEs. That said, we would expect that permanent shocks play a more important role in determining macroeconomic dynamics in EMEs with domestic frictions compared to those with international frictions. Indeed, this is what we find in the following when we take a closer look at the determinants of business cycle fluctuations in emerging markets.

4.4.6 Forecast Error Variance Decomposition

Finally, we investigate the sources of macroeconomic fluctuations in EMEs. For this purpose, we perform a forecast error variance decomposition (FEVD) of the variables in our system. Our analysis focuses on the contemporaneous FEVD, which is presented in Table 4.9.[18]

Various findings are worth emphasising. First, columns 7 to 9 of the table show that permanent shocks are the primary source of output fluctuations in most EMEs. On average, permanent shocks account for about 65 percent of the short–run variability of output. However, we also observe that the importance of this type of shocks varies considerably across countries. For instance, trend shocks account for less than 50 percent of income variation in Argentina, Indonesia, Korea, Peru, and Russia, while they explain more than 90 percent in the Czech Republic, Malaysia, Mexico, and Turkey.

Hence, our results are consistent with the findings of Aguiar and Gopinath (2007) and García-Cicco *et al.* (2010) in this respect, too. Aguiar and Gopinath (2007) show that the Mexican business cycle is mainly driven by trend shocks. Therefore, these authors posit the hypothesis that *"the cycle is the trend"* in emerging markets. García-Cicco *et al.* (2010) challenge this notion by showing that income growth fluctuations in Argentina mainly arise from temporary disturbances. This is exactly what we find in our analysis. It is trend (temporary) shocks that explain almost all the variation in Mexican (Argentine) output. Overall, we conclude that it might be too bold to generally state that *"the cycle is the trend"* in emerging markets. Yet permanent shocks are indeed the main determinant of output fluctuations in many EMEs.

Returning to our previous discussion of domestic versus international frictions in emerging markets, it is now interesting to check how the importance of trend shocks is related to its impact on the current account. To this end, in Figure 4.4 we plot the share of income variation that can be ascribed to the permanent

[18] Forecast error variance decompositions at different forecast horizons for each country can be found in Appendix C.

Table 4.9: Contemporaneous Forecast Error Variance Decomposition

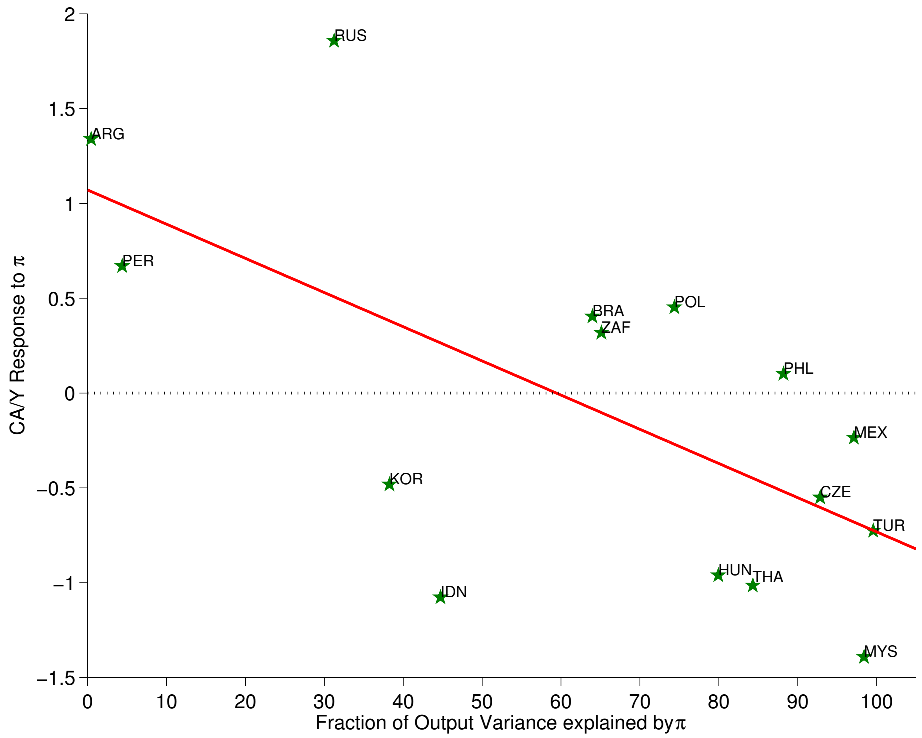
	$r^\star$		$\frac{CA}{Y}$			y		
	π	τ^g	π	τ^g	τ^c	π	τ^g	τ^c
ARG	24.59	75.41	70.65	22.63	6.72	0.44	0.37	99.19
BRA	37.12	62.88	16.88	22.47	60.65	63.98	0.05	35.97
CZE	2.75	97.25	15.98	0.89	83.14	92.86	0.00	7.13
HUN	0.11	99.89	44.95	0.16	54.89	79.94	3.37	16.69
IDN	18.16	81.84	32.96	3.50	63.54	44.72	2.64	52.64
KOR	50.63	49.37	6.95	33.12	59.93	38.26	49.32	12.42
MYS	5.41	94.59	19.05	7.90	73.05	98.41	1.50	0.10
MEX	21.19	78.81	5.49	1.21	93.30	97.13	2.48	0.39
PER	71.37	28.63	24.74	54.21	21.05	4.38	10.90	84.73
PHL	16.58	83.42	0.20	3.14	96.66	88.19	10.58	1.23
POL	0.09	99.91	21.51	1.16	77.33	74.37	0.04	25.59
RUS	0.42	99.58	87.44	2.58	9.98	31.24	4.71	64.05
ZAF	49.53	50.47	4.79	0.10	95.11	65.11	30.82	4.06
THA	20.55	79.45	9.39	4.44	86.17	84.32	7.52	8.16
TUR	0.47	99.53	18.06	3.83	78.12	99.57	0.30	0.13
Median	18.16	81.84	18.06	3.50	73.05	74.37	2.64	12.42
Mean	21.26	78.74	25.27	10.75	63.98	64.19	8.31	27.50
Std. Dev.	22.08	22.08	24.87	15.69	29.72	33.21	13.85	32.80

Notes: Percentage share of the contemporaneous forecast error variance explained by permanent, global transitory, and country–specific transitory shocks.

component against the impact response of the current account to output ratio to a permanent shock. As can be seen from the graph, there seems to be a negative link between the two. In fact, we find a correlation coefficient of −0.64, which is significant at the 5% level. Accordingly, the greater the share of trend shocks in the forecast error variance of output, the smaller or more negative is the change in $\frac{CA}{Y}$ following a permanent disturbance. In other words, if trend shocks drive the countercyclicality of the current account in a country, it is very likely that they also account for a great deal of its business cycle fluctuations. This finding underpins our interpretation of the difference between domestic and international frictions in emerging markets. Macroeconomic fluctuations of countries where domestic (international) frictions are relatively more important tend to be relatively more (less) driven by trend shocks.

Second, for the majority of countries, global shocks account for a rather small fraction of the variation in output. Apart from Korea, Peru, the Philippines, and South Africa, this type of shocks determines less than 10 percent of the

Figure 4.4: Impact Response of $\frac{CA}{Y}$ and Forecast Error Variance Decomposition



Notes: The scatter plot displays the impact impulse response of the current account to output ratio to a permanent shock (vertical axes) and the fraction of contemporaneous output variance explained by permanent shocks. The solid line represents the OLS regression line.

contemporaneous forecast error variance of GDP. Accordingly, changes in the world interest rate, the variable we use to identify global shocks in our analysis, have only a negligible impact on the business cycle in EMEs. In fact, this finding corroborates the results of previous related studies. For instance, Neumeyer and Perri (2005) show that although interest rate shocks explain a considerable share of output variations, it is mainly the country risk component and less the global component of interest rates that matters for the business cycle in Argentina. Likewise, Chang and Férnandez (2013) estimate a DSGE model for the Mexican economy and show that innovations to the world interest rate only marginally contribute to the variability of income. In contrast, Uribe and Yue (2006) find that US interest rate shocks account for as much as 20 percent of macroeconomic fluctuations in selected EMEs. However, these authors also point out that most of this effect is due to the influence of the world interest rate on country spreads.

Third, columns 4 to 6 indicate that a substantial portion of the variation in the current account to income ratio can be attributed to transitory shocks. In particular, country–specific disturbances explain a considerable share of the fluctuation in $\frac{CA}{Y}$. In fact, about three quarter of this variable's variability is determined by idiosyncratic disturbances in the median country. Interestingly, this outcome is concurrent with the crucial message of the present value model of the current account (PVMCA). The PVMCA states that the current account is the transitory part of output, such that international capital flows should only arise from temporary shocks. Furthermore, in line with the prediction of the intertemporal approach to the current account, our findings suggest that global shocks play a fairly marginal role for most EMEs, except for those from South America (Argentina, Brazil, and Peru) and Korea.

4.5 Conclusion

This paper addresses the famous hypothesis that *"the cycle is the trend"* in emerging markets. For this purpose, we estimate a trivariate VECM which consists of the world interest rate, the current account to GDP ratio, and income, for a large cross section of EMEs. We propose an identification scheme of the VECM to detect permanent, global transitory, and country–specific transitory components in the data. When we apply our identification method to model generated data, we find that it performs remarkably well in retrieving the true underlying shocks.

Our empirical exercise suggests that we cannot generally conclude that *"the cycle is the trend"* in emerging markets. In particular, we find that permanent shocks account for the countercyclicality of the current account in half of the countries, whereas idiosyncratic transitory shocks explain this countercyclicality in the other half. We also observe that it is either one of these two types of disturbances that drive the negative correlation between the current account and income, but virtually never both. We argue that different degrees of domestic and international frictions in emerging markets might provide an explanation for this result. Countries in which the countercyclicality of the current account is driven by permanent shocks mainly feature domestic frictions, whereas it is international frictions that are more prevalent in emerging markets in which countercyclicality of the current account arises from transitory shocks.

Furthermore, we find that business cycle fluctuations are mainly determined by permanent shocks in the majority of countries. Yet in some EMEs transitory disturbances account for the lion's share of the short–run variation in income. Interestingly, the share of output fluctuations explained by the permanent component is higher in countries in which the countercyclicality of the current account is driven by permanent shocks. This result underpins our interpretation that the relative importance of domestic and international frictions varies across emerging markets. Overall, we conclude that although EMEs share certain business cycle patterns, there seems to be no common source behind them.

We distinguish between domestic and international frictions, but we cannot say much about which particular types of distortions they present. In order to really understand the determinants of current account dynamics in EMEs, we need to learn more about these frictions. For instance, we might wonder what is the role of financial markets in this context. Do institutional issues matter? How important are policy related factors? We believe that an investigation of these issues is a promising task of future research on business cycles in emerging markets.

Appendix A

Appendix to "Macroeconomic Implications of US Banking Liberalisation"

A.1 The Model

This section presents a detailed description of the model environment.

A.1.1 Households

The economy is inhabited by a representative household with a unit mass of atomistic, identical, infinitely lived members. The household seeks to maximise expected lifetime utility subject to a budget constraint:

$$\begin{aligned}
\max_{c_t^H, d_{t+1}, x_{t+1}, l_t} \quad & \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t^H, 1 - l_t), \\
\text{s.t.} \quad & d_{t+1} + x_{t+1} \int_\iota \nu_t(\iota) d\iota + c_t^H \leq (1 + r_t) d_t + x_t \int_\iota (a_t(\iota) + \nu_t(\iota)) d\iota + w_t l_t.
\end{aligned}$$

The representative household's preferences are characterised by a standard Cobb–Douglas CRRA period utility function:

$$u(c_t^H, 1 - l_t) = \frac{\left((c_t^H)^\xi (1 - l_t)^{1-\xi}\right)^{1-\gamma}}{1 - \gamma}.$$

Notice that γ does not denote the Arrow–Pratt coefficient of relative risk aversion, or equivalently, the inverse of the elasticity of intertemporal substitution. It is easy to show that the coefficient of relative risk aversion with Cobb–Douglas CRRA utility is given by $1-\xi(1-\gamma)$. Recall, the coefficient of relative risk aversion (RRA) is defined as

$$RRA = -c^H \frac{u_{cc}(c^H, 1-l)}{u_c(c^H, 1-l)}$$

where $u_c(c^H, 1-l) = \frac{\partial u(c^H,1-l)}{\partial c^H} = \xi \left((c^H)^{\xi}(1-l)^{1-\xi}\right)^{1-\gamma} \frac{1}{c^H}$ and $u_{cc}(c^H, 1-l) = \frac{\partial^2 u(c^H,1-l)}{\partial (c^H)^2} = (\xi(1-\gamma)-1)\, \xi \left((c^H)^{\xi}(1-l)^{1-\xi}\right)^{1-\gamma} \left(\frac{1}{c^H}\right)^2$. As a result, we get

$$\begin{aligned} RRA &= -c^H \frac{(\xi(1-\gamma)-1)\, \xi \left((c^H)^{\xi}(1-l)^{1-\xi}\right)^{1-\gamma} \left(\frac{1}{c^H}\right)^2}{\xi \left((c^H)^{\xi}(1-l)^{1-\xi}\right)^{1-\gamma} \frac{1}{c^H}} \\ \Leftrightarrow \quad RRA &= -\left(\xi(1-\gamma)-1\right) \\ \Leftrightarrow \quad RRA &= 1-\xi\left(1-\gamma\right). \end{aligned}$$

Likewise, it is straightforward to show that with CRRA utility, the inverse of the RRA equals the elasticity of intertemporal substitution (EIS). The EIS determines by how many percent consumption growth falls if the ratio of marginal utilities increases by one percent:

$$EIS = -\frac{\mathrm{d}\log\left(\frac{c^H_{t+1}}{c^H_t}\right)}{\mathrm{d}\log\left(\frac{u_c(c^H_{t+1},1-l_{t+1})}{u_c(c^H_t,1-l_t)}\right)} = -\left[\frac{\mathrm{d}\log\left(\frac{u_c(c^H_{t+1},1-l_{t+1})}{u_c(c^H_t,1-l_t)}\right)}{\mathrm{d}\log\left(\frac{c^H_{t+1}}{c^H_t}\right)}\right]^{-1}.$$

Hence, we have

$$\begin{aligned} EIS &= -\left[\frac{\mathrm{d}\ \left\{(1-\gamma)\xi\log\left(\frac{c^H_{t+1}}{c^H_t}\right)+(1-\xi)(1-\gamma)\log\left(\frac{1-l_{t+1}}{1-l_t}\right)+\log\left(\frac{c^H_t}{c^H_{t+1}}\right)\right\}}{\mathrm{d}\log\left(\frac{c^H_{t+1}}{c^H_t}\right)}\right]^{-1} \\ \Leftrightarrow \quad EIS &= -\left[(1-\gamma)\xi-1\right]^{-1} \\ \Leftrightarrow \quad EIS &= \frac{1}{1-\xi\left(1-\gamma\right)}. \end{aligned}$$

After this brief digression on RRA and EIS, I now return to the household's optimisation problem. The Lagrangian to this problem can be set up as

$$\mathcal{L} = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \Bigg[\frac{\left((c_t^H)^{\xi}(1-l_t)^{1-\xi}\right)^{1-\gamma}}{1-\gamma}$$
$$+ \lambda_t^H \left((1+r_t)d_t + x_t \int_{\iota} (a_t(\iota) + v_t(\iota))d\iota + w_t l_t - d_{t+1} - x_{t+1} \int_{\iota} v_t(\iota)d\iota - c_t^H \right) \Bigg].$$

First–order conditions (FOCs) of this problem are given by

(I) FOC with respect to consumption

$$\frac{\partial \mathcal{L}}{\partial c_t^H} = \beta^t \left[\left((c_t^H)^{\xi}(1-l_t)^{1-\xi}\right)^{-\gamma} (c_t^H)^{\xi-1}(1-l_t)^{1-\xi}\xi - \lambda_t^H \right] \leq 0$$
$$c_t^H \geq 0, \qquad \frac{\partial \mathcal{L}}{\partial c_t^H} c_t^H = 0$$

$\Rightarrow \quad c_t^H > 0$ and $\frac{\partial \mathcal{L}}{\partial c_t^H} = 0$, such that

$$\lambda_t^H = \frac{\xi\left((c_t^H)^{\xi}(1-l_t)^{1-\xi}\right)^{1-\gamma}}{c_t^H}$$

(II) FOC with respect to labour supply

$$\frac{\partial \mathcal{L}}{\partial l_t} = \beta^t \left[\left((c_t^H)^{\xi}(1-l_t)^{1-\xi}\right)^{-\gamma} (c_t^H)^{\xi}(1-l_t)^{-\xi}(1-\xi)(-1) + \lambda_t^H w_t \right] \leq 0$$
$$l_t \geq 0, \qquad \frac{\partial \mathcal{L}}{\partial l_t} l_t = 0$$

$\Rightarrow \quad l_t > 0$ and $\frac{\partial \mathcal{L}}{\partial l_t} = 0$, such that

$$\lambda_t^H w_t = \frac{(1-\xi)\left((c_t^H)^{\xi}(1-l_t)^{1-\xi}\right)^{1-\gamma}}{1-l_t}$$

(III) FOC with respect to bank deposits

$$\frac{\partial \mathcal{L}}{\partial d_{t+1}} = \beta^t \left[-\lambda_t^H\right] + \beta^{t+1}\mathrm{E}_t \left[\lambda_{t+1}^H(1+r_{t+1})\right] \leq 0$$
$$d_{t+1} \geq 0, \qquad \frac{\partial \mathcal{L}}{\partial d_{t+1}} d_{t+1} = 0$$

$\Rightarrow \quad d_{t+1} > 0$ and $\frac{\partial \mathcal{L}}{\partial d_{t+1}} = 0$, such that

$$\lambda_t^H = \beta(1 + r_{t+1})\mathrm{E}_t\left[\lambda_{t+1}^H\right]$$

(IV) FOC with respect to bank shares

$$\frac{\partial \mathcal{L}}{\partial x_{t+1}} = \beta^t\left[-\lambda_t^H \int_\iota \nu_t(\iota)d\iota\right] + \beta^{t+1}\mathrm{E}_t\left[\lambda_{t+1}^H \int_\iota (a_{t+1}(\iota) + \nu_{t+1}(\iota))\, d\iota\right] \leq 0$$
$$x_{t+1} \geq 0, \qquad \frac{\partial \mathcal{L}}{\partial x_{t+1}} x_{t+1} = 0$$

$\Rightarrow \quad x_{t+1} > 0$ and $\frac{\partial \mathcal{L}}{\partial x_{t+1}} = 0$, such that

$$\lambda_t^H \int_\iota \nu_t(\iota)d\iota = \beta\mathrm{E}_t\left[\lambda_{t+1}^H \int_\iota (a_{t+1}(\iota) + \nu_{t+1}(\iota))\, d\iota\right]$$
$$\Leftrightarrow \qquad \lambda_t^H \nu_t = \beta\mathrm{E}_t\left[\lambda_{t+1}^H(a_{t+1} + \nu_{t+1})\right],$$

where $\int_\iota \nu_t(\iota)d\iota \equiv \nu_t$ and $\int_\iota a_t(\iota)d\iota \equiv a_t$.

From FOCs (I) and (III), we can derive the **intertemporal Euler equation with respect to bank deposits**

$$\frac{\left((c_t^H)^\xi(1 - l_t)^{1-\xi}\right)^{1-\gamma}}{c_t^H} = \beta(1 + r_{t+1})\mathrm{E}_t\left[\frac{\left((c_{t+1}^H)^\xi(1 - l_{t+1})^{1-\xi}\right)^{1-\gamma}}{c_{t+1}^H}\right]. \tag{A.1}$$

Combining FOCs (I) and (IV), we obtain the standard **consumption–based asset pricing formula**

$$\nu_t = \beta\mathrm{E}_t\left[\left(\frac{(c_{t+1}^H)^\xi(1 - l_{t+1})^{1-\xi}}{(c_t^H)^\xi(1 - l_t)^{1-\xi}}\right)^{1-\gamma} \frac{c_t^H}{c_{t+1}^H}(a_{t+1} + \nu_{t+1})\right], \tag{A.2}$$

or, more concisely,

$$\nu_t = \mathrm{E}_t\left[m_{t,t+1}(a_{t+1} + \nu_{t+1})\right],$$

where $m_{t,t+1} = \beta\left(\frac{(c_{t+1}^H)^\xi(1-l_{t+1})^{1-\xi}}{(c_t^H)^\xi(1-l_t)^{1-\xi}}\right)^{1-\gamma} \frac{c_t^H}{c_{t+1}^H}$ determines the SDF between period t and $t+1$.

Finally, using FOCs (I) and (II), we can derive the **intratemporal labour–leisure trade–off**

$$w_t = \frac{1-\xi}{\xi}\frac{c_t^H}{1-l_t}. \tag{A.3}$$

Moreover, the solution to the household's optimisation problem must satisfy the transversality conditions (TVCs):

$$\lim_{T\to\infty} \mathrm{E}_t\left[\prod_{k=1}^{T-1}\frac{d_{t+T}}{1+r_{t+k}}\right] = 0 \quad \text{and} \quad \lim_{T\to\infty} \mathrm{E}_t\left[m_{t,t+T}v_{t+T}\right] = 0,$$

where $m_{t,t+T} = \beta^T \left(\frac{(c_{t+T}^H)^{\xi}(1-l_{t+T})^{1-\xi}}{(c_t^H)^{\xi}(1-l_t)^{1-\xi}}\right)^{1-\gamma} \frac{c_t^H}{c_{t+T}^H}$ is the T period SDF.

The two TVCs have the standard interpretation. The first TVC ensures that the agent does not overaccumulate assets in form of bank deposits. That would not be optimal since the agent could achieve higher expected lifetime utility by decreasing savings and increasing consumption in any point of time. The second TVC rules out bubbles in the stock price of the mutual fund. Bubbles inflate the share price, such that everybody wants to purchase stocks today and resell it at a higher price in the future. Obviously, this cannot be an equilibrium.

A.1.2 Firms

Final Good Producers

The final good is manufactured in a perfect competitive industry. Because of perfect competition and constant returns to scale in the production function, market size is indeterminate, such that we can consider a representative firm. The representative producer assembles differentiated capital good inputs indexed by $\omega \in [0, n_t]$ according to a standard Dixit and Stiglitz (1977) CES production function:

$$y_t = \left(\int_0^{n_t} k_t(\omega)^{\frac{\phi-1}{\phi}} d\omega\right)^{\frac{\phi}{\phi-1}}.$$

Since the producer has to purchase intermediate goods in each period, the representative firm's objective can be described by solving a series of static, one–period profit maximisation problems. Accordingly, the representative producer chooses differentiated intermediate good inputs to maximise profits at each time t:

$$\max_{k_t(\omega)} \quad \left(\int_0^{n_t} k_t(\omega)^{\frac{\phi-1}{\phi}} d\omega\right)^{\frac{\phi}{\phi-1}} - \int_0^{n_t} p_t(\omega)k_t(\omega)d\omega, \qquad \forall\ t = 0, 1, 2, \ldots,$$

where $p_t(\omega)$ denotes the price for variety ω.

FOCs with respect to each specific capital good input $k_t(\omega)$ are given by

$$\frac{\partial \ldots}{\partial k_t(\omega)} = \left(\int_0^{n_t} k_t(\omega)^{\frac{\phi-1}{\phi}} d\omega\right)^{\frac{\phi}{\phi-1}-1} k_t(\omega)^{\frac{\phi-1}{\phi}-1} - p_t(\omega) = 0$$

$$\Leftrightarrow \qquad p_t(\omega) = \left(\frac{y_t}{k_t(\omega)}\right)^{\frac{1}{\phi}}, \qquad \forall\ t = 0, 1, 2, \ldots, \quad \text{and} \quad \omega \in [0, n_t]. \tag{A.4}$$

Intermediate Good Producers

Production technology is linear in the only factor labour, and takes the simple form

$$k_t(\omega) = z_t l_{k,t}(\omega),$$

where z_t denotes labour–augmenting technology. The TFP process z_t can be decomposed into a state–specific component $z_{s,t}$ and a country–wide component $z_{c,t}$, i.e. $z_t = z_{s,t} z_{c,t}$. Both TFP components follow an exogenous AR(1) process in logs:

$$\log(z_{s,t+1}) = (1 - \rho_{z_s}) \log(z_s) + \rho_{z_s} \log(z_{s,t}) + u_{z_s,t+1}, \quad \text{with } |\rho_{z_s}| < 1, \tag{A.5}$$

$$\log(z_{c,t+1}) = (1 - \rho_{z_c}) \log(z_c) + \rho_{z_c} \log(z_{c,t}) + u_{z_c,t+1}, \quad \text{with } |\rho_{z_c}| < 1. \tag{A.6}$$

Producers in the intermediate goods sector act under monopolistic competition. That is, although there exists a continuum of different capital goods, each variety is supplied by a monopolist. This market structure enables them to generate profits. As a consequence, I can formulate the optimisation problem of firm

ω as

$$\max_{p_t(\omega)} \quad p_t(\omega)k_t(\omega) - \frac{w_t}{z_t}k_t(\omega), \quad \forall\, t = 0, 1, 2, \ldots,$$
$$\text{subject to (A.4).}$$

I can rewrite the input demand function in the final good sector (A.4) as $k_t(\omega) = y_t p_t(\omega)^{-\phi}$, and substitute this expression for $k_t(\omega)$ in the objective function. Subsequent differentiation with respect to $p_t(\omega)$ yields the optimal price setting function of firm ω:

$$p_t(\omega) = p_t = \frac{\phi}{\phi - 1}\frac{w_t}{z_t}. \tag{A.7}$$

If I plug equation (A.7) into (A.4), I obtain the demand for a specified capital good ω by the representative final good firm:

$$k_t(\omega) = k_t = \left(\frac{\phi - 1}{\phi}\frac{z_t}{w_t}\right)^{\phi} y_t.$$

Optimality condition (A.7) reveals that price of intermediate good ω is simply determined by a constant mark–up $\frac{\phi}{\phi-1}$ over marginal costs $\frac{w_t}{z_t}$, which are common to all capital good producers. Thus, all intermediate goods producers choose the same price–quantity combination p_t and k_t.

As a consequence, the production function in the final good sector boils down to

$$y_t = n_t^{\frac{\phi}{\phi-1}} k_t, \tag{A.8}$$

and condition (A.4) becomes

$$p_t = \left(\frac{y_t}{k_t}\right)^{\frac{1}{\phi}}. \tag{A.9}$$

Now, I can easily derive firm profits as a function of final output and the number of capital good producers in the economy:

$$\begin{aligned} \pi_t^F &= p_t k_t - \frac{w_t}{z_t}k_t \\ \overset{(A.7)}{\Longleftrightarrow} \qquad &= \frac{1}{\phi}p_t k_t \end{aligned}$$

$$
\begin{aligned}
&\overset{(A.9)}{\iff} \quad = \frac{1}{\phi} y_t^{\frac{1}{\phi}} k_t^{\frac{\phi-1}{\phi}} \\
&\overset{(A.8)}{\iff} \quad = \frac{1}{\phi} \frac{y_t}{n_t}.
\end{aligned} \tag{A.10}
$$

A.1.3 Entrepreneurs

There is a fixed discrete number μ_E of entrepreneurs in the economy. Each entrepreneur j faces the optimisation problem

$$
\begin{aligned}
\max_{c_t^E(j), b_{t+1}(j), n_{t+1}(j), n_{e,t}(j)} \quad & \mathrm{E}_0 \sum_{t=0}^{\infty} \beta_E^t \left[\frac{(c_t^E(j))^{1-\gamma_E}}{1-\gamma_E} \right], \\
\text{subject to} \quad & c_t^E(j) + n_{e,t}(j) + (1 + r_t^b) b_t(j) + \frac{\chi}{2} \left(\frac{n_{e,t}(j)}{n_t(j)} \right)^2 n_t(j) \leq n_t(j) \pi_t^F + b_{t+1}(j), \\
& n_{t+1}(j) = (1-\delta) n_t(j) + n_{e,t}(j), \\
\text{and} \quad & (1 + r_{t+1}^b) b_{t+1}(j) \leq \kappa_t n_t(j) \mathrm{E}_t \left[n_{t+1}(j) \pi_{t+1}^F \right],
\end{aligned}
$$

where κ_t is an exogenous collateral shock variable, which follows an AR(1) process in logs:

$$
\log(\kappa_{t+1}) = (1-\rho_\kappa) \log(\kappa) + \rho_\kappa \log(\kappa_t) + u_{\kappa,t+1}, \quad \text{with } |\rho_\kappa| < 1. \tag{A.11}
$$

The Lagrangian to this problem can be set up as

$$
\begin{aligned}
\mathcal{L} = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta_E^t \Bigg[& \frac{(c_t^E(j))^{1-\gamma_E}}{1-\gamma_E} \\
& + \lambda_t^E(j) \left(n_t(j) \pi_t^F + b_{t+1}(j) - n_{e,t}(j) - (1 + r_t^b) b_t(j) - \frac{\chi}{2} \left(\frac{n_{e,t}(j)}{n_t(j)} \right)^2 n_t(j) - c_t^E(j) \right) \\
& + q_t(j) \left((1-\delta) n_t(j) + n_{e,t}(j) - n_{t+1}(j) \right) \\
& + \mu_t(j) \left(\kappa_t n_t(j) \left[n_{t+1}(j) \pi_{t+1}^F \right] - (1 + r_{t+1}^b) b_{t+1}(j) \right) \Bigg],
\end{aligned}
$$

which implies the following FOCs:

(I) FOC with respect to consumption

$$\frac{\partial \mathcal{L}}{\partial c_t^E(j)} = \beta_E^t \left[(c_t^E(j))^{-\gamma_E} - \lambda_t^E(j) \right] \leq 0$$
$$c_t^E(j) \geq 0, \qquad \frac{\partial \mathcal{L}}{\partial c_t^E(j)} c_t^E(j) = 0$$

$\Rightarrow \quad c_t^E(j) > 0$ and $\frac{\partial \mathcal{L}}{\partial c_t^E(j)} = 0$, such that

$$\lambda_t^E(j) = (c_t^E(j))^{-\gamma_E}$$

(II) FOC with respect to loan demand

$$\frac{\partial \mathcal{L}}{\partial b_{t+1}(j)} = \beta_E^t \left[\lambda_t^E(j) - \mu_t(j)(1 + r_{t+1}^b) \right] + \beta_E^{t+1} \mathrm{E}_t \left[\lambda_{t+1}^E(j)(-(1 + r_{t+1}^b) \right] \leq 0$$
$$b_{t+1}(j) \geq 0, \qquad \frac{\partial \mathcal{L}}{\partial b_{t+1}(j)} b_{t+1}(j) = 0$$

$\Rightarrow \quad b_{t+1}(j) > 0$ and $\frac{\partial \mathcal{L}}{\partial b_{t+1}(j)} = 0$, such that

$$\lambda_t^E(j) - \mu_t(j)(1 + r_{t+1}^b) = \beta_E(1 + r_{t+1}^b)\mathrm{E}_t \left[\lambda_{t+1}^E(j) \right]$$

(III) FOC with respect to firm number

$$\begin{aligned} \frac{\partial \mathcal{L}}{\partial n_{t+1}(j)} = {} & \beta_E^t \left[-q_t(j) + \mu_t(j)\kappa_t n_t(j) \mathrm{E}_t \left[\pi_{t+1}^F + n_{t+1}(j) \frac{\partial \pi_{t+1}^F}{\partial n_{t+1}} \frac{\partial n_{t+1}}{\partial n_{t+1}(j)} \right] \right] \\ & + \beta_E^{t+1} \mathrm{E}_t \Bigg[\lambda_{t+1}^E(j) \left(\pi_{t+1}^F + n_{t+1}(j) \frac{\partial \pi_{t+1}^F}{\partial n_{t+1}} \frac{\partial n_{t+1}}{\partial n_{t+1}(j)} + \frac{\chi}{2} \left(\frac{n_{e,t+1}(j)}{n_{t+1}(j)} \right)^2 \right) \\ & + q_{t+1}(j)(1 - \delta) + \mu_{t+1}(j)\kappa_{t+1} n_{t+2}(j) \pi_{t+2}^F \Bigg] \leq 0 \end{aligned}$$
$$n_{t+1}(j) \geq 0, \qquad \frac{\partial \mathcal{L}}{\partial n_{t+1}(j)} n_{t+1}(j) = 0$$

$\Rightarrow \quad n_{t+1}(j) > 0$ and $\frac{\partial \mathcal{L}}{\partial n_{t+1}(j)} = 0$, such that

$$q_t(j) - \mu_t(j)\mathrm{E}_t\left[\kappa_t n_t(j)\left(\pi^F_{t+1} + \underbrace{n_{t+1}(j)\frac{\partial \pi^F_{t+1}}{\partial n_{t+1}}\frac{\partial n_{t+1}}{\partial n_{t+1}(j)}}_{\text{Profit Destruction Externality}}\right)\right]$$

$$= \beta_E \mathrm{E}_t\Bigg[\lambda^E_{t+1}(j)\left(\pi^F_{t+1} + \underbrace{n_{t+1}(j)\frac{\partial \pi^F_{t+1}}{\partial n_{t+1}}\frac{\partial n_{t+1}}{\partial n_{t+1}(j)}}_{\text{Profit Destruction Externality}} + \frac{\chi}{2}\left(\frac{n_{e,t+1}(j)}{n_{t+1}(j)}\right)^2\right)$$

$$+ q_{t+1}(j)(1-\delta) + \mu_{t+1}(j)\kappa_{t+1}n_{t+2}(j)\pi^F_{t+2}\Bigg]$$

(IV) FOC with respect to firm entrants

$$\frac{\partial \mathcal{L}}{\partial n_{e,t}(j)} = \beta^t_E\left[\lambda^E_t(j)\left(-1 - \chi\frac{n_{e,t}(j)}{n_t(j)}\right) + q_t(j)\right] \leq 0$$

$$n_{e,t}(j) \geq 0, \qquad \frac{\partial \mathcal{L}}{\partial n_{e,t}(j)} n_{e,t}(j) = 0$$

$\Rightarrow \quad n_{e,t}(j) > 0$ and $\frac{\partial \mathcal{L}}{\partial n_{e,t}(j)} = 0$, such that

$$\lambda^E_t(j)\left(1 + \chi\frac{n_{e,t}(j)}{n_t(j)}\right) = q_t(j)$$

(V) FOC with respect to the Lagrange multiplier on the borrowing constraint

$$\frac{\partial \mathcal{L}}{\partial \mu_t(j)} = \left(\kappa_t n_t(j)\mathrm{E}_t\left[n_{t+1}(j)\pi^F_{t+1}\right] - (1 + r^b_{t+1})b_{t+1}(j)\right) \geq 0$$

$$\mu_t(j) \geq 0, \qquad \frac{\partial \mathcal{L}}{\partial \mu_t(j)}\mu_t(j) = 0$$

$\Rightarrow \quad \mu_t(j)\left(\kappa_t n_t(j)\mathrm{E}_t\left[n_{t+1}(j)\pi^F_{t+1}\right] - (1 + r^b_{t+1})b_{t+1}(j)\right) = 0.$

Next, I impose symmetry across entrepreneurs. Accordingly, we have $n_t = \sum_j^{\mu_E} n_t(j) = \mu_E n_t(j)$, $c^E_t(j) = c^E_t$, $b_t(j) = \frac{1}{\mu_E}b_t$, $n_{e,t}(j) = \frac{1}{\mu_E}n_{e,t}$, $q_t(j) = q_t$, and $\mu_t(j) = \mu_t$. The Profit Destruction Externality (PDE) of creating a new enterprise in FOC (III) can now be calculated as

$$\begin{aligned}
n_{t+1}(j)\frac{\partial \pi^F_{t+1}}{\partial n_{t+1}}\frac{\partial n_{t+1}}{\partial n_{t+1}(j)} &= -\frac{1}{\phi}\frac{y_{t+1}}{n^2_{t+1}}n_{t+1}(j) \\
\Leftrightarrow \qquad &= -\frac{1}{\phi}\frac{y_{t+1}}{n_{t+1}}\frac{n_{t+1}(j)}{n_{t+1}} \\
\overset{(A.10)}{\Longleftrightarrow} \qquad &= -\pi^F_{t+1}\frac{1}{\mu_E}.
\end{aligned}$$

As a consequence, combining FOCs (I) and (II) yields the **intertemporal consumption Euler equation**

$$(c^E_t)^{-\gamma_E} = \beta_E(1+r^b_{t+1})\mathrm{E}_t\left[(c^E_{t+1})^{-\gamma_E}\right] + \mu_t(1+r^b_{t+1}). \tag{A.12}$$

From FOCs (I) and (III), we obtain the **intertemporal investment Euler equation**

$$\begin{aligned}
q_t = \beta_E \mathrm{E}_t\Bigg[&(c^E_{t+1})^{-\gamma_E}\Bigg(\left(1-\frac{1}{\mu_E}\right)\pi^F_{t+1} + \frac{\chi}{2}\left(\frac{n_{e,t+1}}{n_{t+1}}\right)^2\Bigg) + (1-\delta)q_{t+1}\Bigg] \\
&+\mu_t\kappa_t n_t\left(1-\frac{1}{\mu_E}\right)\mathrm{E}_t\left[\pi^F_{t+1}\right] + \beta_E\mathrm{E}_t\Big[\mu_{t+1}\kappa_{t+1}n_{t+2}\pi^F_{t+2}\Big].
\end{aligned} \tag{A.13}$$

Using FOCs (I) and (IV), we can derive the **firm entry condition**

$$q_t = (c^E_t)^{-\gamma_E}\left(1+\chi\frac{n_{e,t}}{n_t}\right). \tag{A.14}$$

Finally, FOC (V) defines the complementary slackness condition of the borrowing limit

$$\mu_t\left(\kappa_t n_t \mathrm{E}_t\left[n_{t+1}\pi^F_{t+1}\right] - (1+r^b_{t+1})b_{t+1}\right) = 0. \tag{A.15}$$

In addition to conditions (A.12)–(A.15), optimal behaviour of entrepreneurs must satisfy the resource constraint and the TVC $\lim_{T\to\infty}\mathrm{E}_t\left[\prod_{k=1}^{T-1}\frac{b_{t+T}}{1+r^b_{t+k}}\right] = 0$. Besides, the dynamic equation for the overall number of intermediate good producing firms in the economy is given by

$$n_{t+1} = n_{e,t} + (1-\delta)n_t. \tag{A.16}$$

A.1.4 Banks

There is monopolistic competition in the credit market. Entrepreneurs demand all varieties of differentiated bank loans, which are aggregated according to a Dixit and Stiglitz (1977) CES aggregator:

$$b_{t+1} = \left(\int_{\iota} b_{t+1}(\iota)^{\frac{\epsilon_t - 1}{\epsilon_t}} d\iota \right)^{\frac{\epsilon_t}{\epsilon_t - 1}},$$

where b_{t+1} is total demand for bank loans, and $b_{t+1}(\iota)$ denotes a specific variety of bank loan supplied by bank ι. Parameter $\epsilon_t > 1$ determines the elasticity of substitution between differentiated loans, which follows an AR(1) process in logs:

$$\log(\epsilon_{t+1}) = (1 - \rho_\epsilon)\log(\epsilon) + \rho_\epsilon \log(\epsilon_t) + u_{\epsilon,t+1}, \quad \text{with } |\rho_\epsilon| < 1. \tag{A.17}$$

To derive the loan demand faced by an individual bank ι, I have to solve the cost minimisation problem of borrowers. In each period t, a borrower seeks to minimise her net loan repayment, subject to the CES loan aggregator, by choosing the amount of each differentiated loan $b_{t+1}(\iota)$:

$$\begin{aligned} \min_{b_{t+1}(\iota)} \quad & r^b_{t+1} b_{t+1} = \int_{\iota} r^b_{t+1}(\iota) b_{t+1}(\iota) d\iota, \\ \text{subject to} \quad & \left(\int_{\iota} b_{t+1}(\iota)^{\frac{\epsilon_t - 1}{\epsilon_t}} d\iota \right)^{\frac{\epsilon_t}{\epsilon_t - 1}} = b_{t+1}. \end{aligned}$$

The Langrangian to this problem can be set up as

$$\mathcal{L} = \int_{\iota} r^b_{t+1}(\iota) b_{t+1}(\iota) d\iota - \zeta \left[b_{t+1} - \left(\int_{\iota} b_{t+1}(\iota)^{\frac{\epsilon_t - 1}{\epsilon_t}} d\iota \right)^{\frac{\epsilon_t}{\epsilon_t - 1}} \right],$$

where ζ denotes the Lagrange multiplier. The FOC for the loan supplied by bank ι is then given by

$$\begin{aligned} r^b_{t+1}(\iota) &= -\zeta \left(\int_{\iota} b_{t+1}(\iota)^{\frac{\epsilon_t - 1}{\epsilon_t}} \right)^{\frac{1}{\epsilon_t - 1}} b_{t+1}(\iota)^{-\frac{1}{\epsilon_t}} \\ \Leftrightarrow \qquad r^b_{t+1}(\iota) &= -\zeta b_{t+1}^{\frac{1}{\epsilon_t}} b_{t+1}(\iota)^{-\frac{1}{\epsilon_t}}. \end{aligned}$$

Rearranging terms yields the demand for the differentiated loan from bank ι:

$$b_{t+1}(\iota) = \left(\frac{r^b_{t+1}(\iota)}{r^b_{t+1}}\right)^{-\epsilon_t} b_{t+1},$$

where I have substituted r^b_{t+1} for the negative value of the Lagrange multiplier ζ. Notice that the Lagrange multiplier determines the cost increase associated with the demand for additional marginal unit of debt. Hence, $-\zeta$ can be interpreted as the shadow price of loan demand as it represents the marginal cost of an extra unit of debt. Since aggregation of loans is perfectly competitive, optimality requires that price equals marginal costs, i.e. $r^b_{t+1} \stackrel{!}{=} -\zeta$.

As a final step, I can derive an explicit expression for the average loan interest rate r^b_{t+1}. To this end, I plug the individual loan demand function into the cost equation in order to derive the cost function:

$$\begin{aligned}
r^b_{t+1} b_{t+1} &= \int_\iota r^b_{t+1}(\iota) b_{t+1}(\iota) d\iota \\
\Leftrightarrow \qquad &= \int_\iota r^b_{t+1}(\iota) \left(\frac{r^b_{t+1}(\iota)}{r^b_{t+1}}\right)^{-\epsilon_t} b_{t+1} d\iota \\
\Leftrightarrow \qquad &= \underbrace{\int_\iota r^b_{t+1}(\iota)^{1-\epsilon_t} d\iota (r^b_{t+1})^{\epsilon_t}}_{=r^b_{t+1}} b_{t+1}.
\end{aligned}$$

From this expression, I can now easily solve for r^b_{t+1}:

$$\begin{aligned}
r^b_{t+1} &= \int_\iota r^b_{t+1}(\iota)^{1-\epsilon_t} d\iota (r^b_{t+1})^{\epsilon_t} \\
\Leftrightarrow \qquad r^b_{t+1} &= \left(\int_\iota r^b_{t+1}(\iota)^{1-\epsilon_t} d\iota\right)^{\frac{1}{1-\epsilon_t}}.
\end{aligned}$$

Note that from the demand function of individual bank loans, we can easily show that the elasticity of substitution between differentiated loans is indeed given by ϵ_t. The elasticity of substitution defines by how many percent relative demand for bank loan ι changes if the relative loan interest rate of bank ι increases by one percent. More formally, the substitution elasticity is given by

$$
\begin{aligned}
& -\frac{\mathrm{d}\ \log\left(\frac{b_{t+1}(\iota)}{b_{t+1}(\iota')}\right)}{\mathrm{d}\ \log\left(\frac{r^b_{t+1}(\iota)}{r^b_{t+1}(\iota')}\right)} = -\frac{\mathrm{d}\ \log\left(\frac{\left(\frac{r^b_{t+1}(\iota)}{r^b_{t+1}}\right)^{-\epsilon_t} b_{t+1}}{\left(\frac{r^b_{t+1}(\iota')}{r^b_{t+1}}\right)^{-\epsilon_t} b_{t+1}}\right)}{\mathrm{d}\ \log\left(\frac{r^b_{t+1}(\iota)}{r^b_{t+1}(\iota')}\right)} \\
\Leftrightarrow \qquad & -\frac{\mathrm{d}\ \log\left(\frac{b_{t+1}(\iota)}{b_{t+1}(\iota')}\right)}{\mathrm{d}\ \log\left(\frac{r^b_{t+1}(\iota)}{r^b_{t+1}(\iota')}\right)} = -\frac{\mathrm{d}\ \log\left(\frac{r^b_{t+1}(\iota)}{r^b_{t+1}(\iota')}\right)^{-\epsilon_t}}{\mathrm{d}\ \log\left(\frac{r^b_{t+1}(\iota)}{r^b_{t+1}(\iota')}\right)} \\
\Leftrightarrow \qquad & -\frac{\mathrm{d}\ \log\left(\frac{b_{t+1}(\iota)}{b_{t+1}(\iota')}\right)}{\mathrm{d}\ \log\left(\frac{r^b_{t+1}(\iota)}{r^b_{t+1}(\iota')}\right)} = -\frac{-\epsilon_t \mathrm{d}\ \log\left(\frac{r^b_{t+1}(\iota)}{r^b_{t+1}(\iota')}\right)}{\mathrm{d}\ \log\left(\frac{r^b_{t+1}(\iota)}{r^b_{t+1}(\iota')}\right)} \\
\Leftrightarrow \qquad & -\frac{\mathrm{d}\ \log\left(\frac{b_{t+1}(\iota)}{b_{t+1}(\iota')}\right)}{\mathrm{d}\ \log\left(\frac{r^b_{t+1}(\iota)}{r^b_{t+1}(\iota')}\right)} = \epsilon_t.
\end{aligned}
$$

Next, I can turn to the optimisation problem of banks. Each financial intermediary seeks to maximise the discounted stream of expected future cash flows to its shareholders. The cash flow to stock owners in each period is the dividend payment, such that the optimisation problem of bank ι can be stated as

$$
\begin{aligned}
\max_{b_{t+1}(\iota), d_{t+1}(\iota)} \quad & \mathrm{E}_0 \sum_{t=0}^{\infty} m_{0,t} a_t(\iota), \\
\text{subject to} \quad \pi^B_t(\iota) &= (1 + r^b_t(\iota)) b_t(\iota) + d_{t+1}(\iota) - (1 + r_t) d_t(\iota) - b_{t+1}(\iota) - \Theta_t(\iota), \\
k^B_{t+1}(\iota) &= (1 - \delta^B) k^B_t(\iota) + \pi^B_t(\iota) - a_t(\iota), \\
b_t(\iota) &= k^B_t(\iota) + d_t(\iota), \\
b_{t+1}(\iota) &= \left(\frac{r^b_{t+1}(\iota)}{r^b_{t+1}}\right)^{-\epsilon_t} b_{t+1}, \\
\Theta_t(\iota) &= \theta_0 \left(\frac{1}{b_t(\iota)} \frac{b_{t+1}(\iota)}{k^B_{t+1}(\iota)}\right)^{\theta_1}.
\end{aligned}
$$

I can substitute for $a_t(\iota)$, $\pi_t^B(\iota)$, $\Theta_t(\iota)$, $d_{t+1}(\iota)$, and $b_{t+1}(\iota)$ in the objective function. This simplifies the problem to

$$\max_{r^b_{t+1}(\iota),k^B_{t+1}(\iota)} \quad \mathrm{E}_0 \sum_{t=0}^{\infty} m_{0,t}\Bigg[(r_t^b(\iota)-r_t)\left(\frac{r_t^b(\iota)}{r_t^b}\right)^{-\epsilon_{t-1}} b_t - 2k^B_{t+1}(\iota) + (2+r_t-\delta^B)k_t^B(\iota) \\ - \theta_0\left(\left(\frac{r^b_{t+1}(\iota)}{r^b_{t+1}}\right)^{-\epsilon_t} b_{t+1}\frac{1}{k^B_{t+1}(\iota)}\left(\frac{r_t^b(\iota)}{r_t^b}\right)^{\epsilon_{t-1}} b_t^{-1}\right)^{\theta_1}\Bigg].$$

FOCs to this optimisation problem are given by

(I) FOC with respect to loan interest rate

$$\begin{aligned}\frac{\partial \ldots}{\partial r^b_{t+1}(\iota)} =& m_{0,t}\mathrm{E}_t\left[\theta_0\theta_1\left(\frac{b_{t+1}(\iota)}{b_t(\iota)k^B_{t+1}(\iota)}\right)^{\theta_1-1}(\epsilon_t)b_{t+1}(\iota)\frac{1}{r^b_{t+1}(\iota)}\frac{1}{k^B_{t+1}(\iota)}\frac{1}{b_t(\iota)}\right] \\ &+ \mathrm{E}_t\Bigg[m_{0,t+1}\Bigg(b_{t+1}(\iota)+(r^b_{t+1}(\iota)-r_{t+1})(-\epsilon_t)b_{t+1}(\iota)\frac{1}{r^b_{t+1}(\iota)} \\ &- \theta_0\theta_1\left(\frac{b_{t+2}(\iota)}{b_{t+1}(\iota)k^B_{t+2}(\iota)}\right)^{\theta_1-1}\frac{b_{t+2}(\iota)}{k^B_{t+2}(\iota)}\epsilon_t b_{t+1}(\iota)^{-1}\frac{1}{r^b_{t+1}(\iota)}\Bigg)\Bigg] = 0\end{aligned}$$

$$\begin{aligned}\Leftrightarrow \quad \theta_0\theta_1\epsilon_t\left(\frac{b_{t+1}(\iota)}{b_t(\iota)k^B_{t+1}(\iota)}\right)^{\theta_1} =& \mathrm{E}_t\Bigg[m_{t,t+1}\Bigg(-b_{t+1}(\iota)r^b_{t+1}(\iota) \\ &+ \epsilon_t(r^b_{t+1}(\iota)-r_{t+1})b_{t+1}(\iota)+\theta_0\theta_1\left(\frac{b_{t+2}(\iota)}{b_{t+1}(\iota)k^B_{t+2}(\iota)}\right)^{\theta_1}\epsilon_t\Bigg)\Bigg]\end{aligned}$$

$$\begin{aligned}\Leftrightarrow \quad \mathrm{E}_t\left[m_{t,t+1}r^b_{t+1}(\iota)b_{t+1}(\iota)\right] =& \frac{\epsilon_t}{\epsilon_t-1}\mathrm{E}_t\Bigg[m_{t,t+1}\Bigg(r_{t+1}b_{t+1}(\iota) \\ &- \theta_0\theta_1\left(\frac{b_{t+2}(\iota)}{b_{t+1}(\iota)k^B_{t+2}(\iota)}\right)^{\theta_1}\Bigg)+\theta_0\theta_1\left(\frac{b_{t+1}(\iota)}{b_t(\iota)k^B_{t+1}(\iota)}\right)^{\theta_1}\Bigg].\end{aligned}$$

Symmetry among banks and normalisation of the measure of banks to one imply that $r^b_{t+1}(\iota) = r^b_{t+1}$, $b_{t+1}(\iota) = b_{t+1}$, $d_{t+1}(\iota) = d_{t+1}$, $k^B_{t+1}(\iota) = k^B_{t+1}$, and $\pi^B_{t+1}(\iota) = \pi^B_{t+1}$. Hence, we get the optimality condition with respect to the loan interest rate as

$$\begin{aligned}\mathrm{E}_t\left[m_{t,t+1}r^b_{t+1}b_{t+1}\right] =& \frac{\epsilon_t}{\epsilon_t-1}\mathrm{E}_t\Bigg[m_{t,t+1}r_{t+1}b_{t+1}+\theta_0\theta_1\Bigg(\left(\frac{b_{t+1}}{b_tk^B_{t+1}}\right)^{\theta_1} \\ &- m_{t,t+1}\left(\frac{b_{t+2}}{b_{t+1}k^B_{t+2}}\right)^{\theta_1}\Bigg)\Bigg].\end{aligned}$$

Note that in principle it is not possible to solve this equation for r^b_{t+1} explicitly because for two random variables x and y, we have $\mathrm{E}[xy] \neq \mathrm{E}[x]\mathrm{E}[y]$, unless $Cov(x, y) = 0$.[1] Nevertheless, since I will later use a first–order approximation of the solution of the model, I can actually ignore the covariance term. Furthermore, using equation (A.1) I can then substitute for the SDF $\mathrm{E}_t\left[m_{t,t+1}\right] = \mathrm{E}_t\left[\beta\left(\frac{(c^H_{t+1})^{\xi}(1-l_{t+1})^{1-\xi}}{(c^H_t)^{\xi}(1-l_t)^{1-\xi}}\right)^{1-\gamma}\frac{c^H_t}{c^H_{t+1}}\right] = \frac{1}{1+r_{t+1}}$. For ease of interpretation, I therefore solve the FOC for r^b_{t+1} to finally get

$$r^b_{t+1} = \frac{\epsilon_t}{\epsilon_t - 1}\mathrm{E}_t \underbrace{\left[r_{t+1} + \frac{\theta_0\theta_1}{b_{t+1}}\left(\left(\frac{b_{t+1}}{b_t k^B_{t+1}}\right)^{\theta_1}(1 + r_{t+1}) - \left(\frac{b_{t+2}}{b_{t+1}k^B_{t+2}}\right)^{\theta_1}\right)\right]}_{\text{Marginal Cost of Lending}}. \tag{A.18}$$

(II) FOC with respect to bank capital

$$\begin{aligned}\frac{\partial \ldots}{\partial k^B_{t+1}(\iota)} = m_{0,t}\Bigg(-2 + \theta_0\theta_1\left(\frac{b_{t+1}(\iota)}{b_t(\iota)k^B_{t+1}(\iota)}\right)^{\theta_1-1}\left(\frac{b_{t+1}(\iota)}{b_t(\iota)k^B_{t+1}(\iota)}\right)\Bigg)& \\ + \mathrm{E}_t\left[m_{0,t+1}\Big(2 + r_{t+1} - \delta^B\Big)\right] = 0&\end{aligned}$$

$$\Leftrightarrow \quad 2 = \theta_0\theta_1\left(\frac{b_{t+1}(\iota)}{b_t(\iota)k^B_{t+1}(\iota)}\right)^{\theta_1}\frac{1}{k^B_{t+1}(\iota)} + \mathrm{E}_t\left[m_{t,t+1}\right](2 + r_{t+1} - \delta^B)$$

$$\begin{aligned}\Leftrightarrow \quad 2 = {}& \theta_0\theta_1\left(\frac{b_{t+1}(\iota)}{b_t(\iota)k^B_{t+1}(\iota)}\right)^{\theta_1}\frac{1}{k^B_{t+1}(\iota)} \\ &+ \mathrm{E}_t\left[\beta\left(\frac{(c^H_{t+1})^{\xi}(1 - l_{t+1})^{1-\xi}}{(c^H_t)^{\xi}(1 - l_t)^{1-\xi}}\right)^{1-\gamma}\frac{c^H_t}{c^H_{t+1}}\right](2 + r_{t+1} - \delta^B)\end{aligned}$$

$$\overset{(A.1)}{\Longleftrightarrow} \quad 2 = \theta_0\theta_1\left(\frac{b_{t+1}(\iota)}{b_t(\iota)k^B_{t+1}(\iota)}\right)^{\theta_1}\frac{1}{k^B_{t+1}(\iota)} + \frac{1}{1 + r_{t+1}}(2 + r_{t+1} - \delta^B).$$

Again, using the fact that the number of banks is normalised to one and imposing symmetry across banks yields

$$2 = \underbrace{\frac{\theta_0\theta_1}{k^B_{t+1}}\left(\frac{b_{t+1}}{b_t k^B_{t+1}}\right)^{\theta_1} + \frac{2 + r_{t+1} - \delta^B}{1 + r_{t+1}}}_{\text{Marginal Benefit of Bank Capital}}. \tag{A.19}$$

[1]The general formula for the expected value of the product of two random random variables x and y is $\mathrm{E}[xy] = \mathrm{E}[x]\mathrm{E}[y] + Cov(x, y)$.

Furthermore, symmetry implies that the bank balance sheet, the dynamic equation for bank capital, and bank profits simplify to

$$b_t = k_t^B + d_t, \tag{A.20}$$

$$k_{t+1}^B = (1 - \delta^B) k_t^B + \pi_t^B - a_t, \tag{A.21}$$

and

$$\pi_t^B = \left(1 + r_t^b\right) b_t + d_{t+1} - (1 + r_t)\, d_t - b_{t+1} - \Theta_t, \tag{A.22}$$

respectively.

A.1.5 General Equilibrium

Equilibrium requires that $x_t = x_{t+1} = 1$. Accordingly, the budget constraint of private households becomes

$$c_t^H + d_{t+1} = (1 + r_t) d_t + a_t + w_t l_t. \tag{A.23}$$

The budget constraint of an individual entrepreneur is

$$c_t^E + \frac{1}{\mu_E} n_{e,t} + (1 + r_t^b) \frac{1}{\mu_E} b_t + \frac{\chi}{2} \frac{1}{\mu_E} \left(\frac{n_{e,t}}{n_t}\right)^2 n_t = \frac{1}{\mu_E} n_t \pi_t^F + \frac{1}{\mu_E} b_{t+1},$$

such that the aggregate budget constraint of entrepreneurs can be written as

$$\mu_E c_t^E + n_{e,t} + (1 + r_t^b) b_t + \frac{\chi}{2} \left(\frac{n_{e,t}}{n_t}\right)^2 n_t = n_t \pi_t^F + b_{t+1}. \tag{A.24}$$

From (A.20), (A.21), (A.22), (A.23), and (A.24) I can derive the aggregate resource constraint of the economy as

$$c_t^H + \mu_E c_t^E + n_{e,t} + \frac{\chi}{2} \left(\frac{n_{e,t}}{n_t}\right)^2 n_t + \Theta_t + k_{t+1}^B - (1 - \delta^B) k_t^B = w_t l_t + n_t \pi_t^F. \tag{A.25}$$

Final good market clearing requires that

$$y_t = w_t l_t + n_t \pi_t^F. \tag{A.26}$$

According to Walras' Law, once all markets for goods and assets are in equilibrium, the labour market will be cleared implicitly:

$$l_t = \frac{1}{z_t} n_t k_t. \tag{A.27}$$

A.1.6 Model Solution

The model constitutes a stationary system of 24 non–linear expectational difference equations in 24 variables. The model features 4 exogenous state variables, 5 endogenous state variables, and 15 controls:

- Vector of exogenous state variables:
  $\mathbf{x}_{x,t} = [z_{s,t} \quad z_{c,t} \quad \epsilon_t \quad \kappa_t]'$
- Vector of endogenous state variables:
  $\mathbf{x}_{e,t} = \left[r_t \quad b_t \quad n_t \quad k_t^B \quad r_t^b\right]'$
- Vector of endogenous control variables:
  $\mathbf{x}_{c,t} = \left[c_t^H \quad c_t^E \quad w_t \quad \pi_t^F \quad \pi_t^B \quad \nu_t \quad y_t \quad q_t \quad k_t \quad p_t \quad l_t \quad n_{e,t} \quad \mu_t \quad d_t \quad a_t\right]'$.

The system of equations incorporates (A.1), (A.2), (A.3), (A.5), (A.6), (A.7), (A.8), (A.9), (A.10), (A.11), (A.12), (A.13), (A.14), (A.15), (A.16), (A.17), (A.18), (A.19), (A.20), (A.21), (A.22), (A.24), (A.25), and (A.26).

Unfortunately, the model does not have a closed form solution. Therefore, I have to approximate its solution. I use a first–order approximation of the model solution.

First, I log–linearise the system around its deterministic steady state, which will be derived in Section A.2. To illustrate the straightforward concept of log–linearisation, it is convenient to consider a system of only two variables z and y. I can write the system as an implicit function

$$f(z, y) = 0,$$

where z and y denote steady state values. Next, I can take the total differential to get

$$\begin{aligned} & \frac{\partial f(z,y)}{\partial z}\mathrm{d}z_t + \frac{\partial f(z,y)}{\partial y}\mathrm{d}y_t = 0 \\ \Leftrightarrow \quad & \frac{\partial f(z,y)}{\partial z} z \frac{\mathrm{d}z_t}{z} + \frac{\partial f(z,y)}{\partial y} y \frac{\mathrm{d}y_t}{y} = 0. \end{aligned}$$

Let $\widehat{z_t}$ denote log–deviations from the steady state. That is,

$$\widehat{z_t} \equiv \log\left(\frac{z_t}{z}\right) \approx \frac{z_t - z}{z} = \frac{\mathrm{d}z_t}{z}.$$

Consequently, the total differential from above can be rewritten as

$$0 = \frac{\partial f(z,y)}{\partial z} z \frac{\mathrm{d}z_t}{z} + \frac{\partial f(z,y)}{\partial y} y \frac{\mathrm{d}y_t}{y} \approx \left(\frac{\partial f(z,y)}{\partial z} z\right)\widehat{z_t} + \left(\frac{\partial f(z,y)}{\partial y} y\right)\widehat{y_t}.$$

Accordingly, log–linearisation of the model at hand yields a linear system of (expectational) difference equations of the form

$$\widetilde{\mathbf{A}}\, \mathrm{E}_t\left[\widehat{\mathbf{x}}_{t+1}\right] = \widetilde{\mathbf{B}}\, \widehat{\mathbf{x}}_t,$$

where

$$\mathrm{E}_t\left[\widehat{\mathbf{x}}_{t+1}\right] = \begin{bmatrix} \mathrm{E}_t\left[\widehat{\mathbf{x}}_{e,t+1}\right] \\ \mathrm{E}_t\left[\widehat{\mathbf{x}}_{x,t+1}\right] \\ \mathrm{E}_t\left[\widehat{\mathbf{x}}_{c,t+1}\right] \end{bmatrix} = \begin{bmatrix} \mathrm{E}_t\left[\widehat{\mathbf{x}}_{s,t+1}\right] \\ \mathrm{E}_t\left[\widehat{\mathbf{x}}_{c,t+1}\right] \end{bmatrix},$$

and $\widehat{\mathbf{x}}_{s,t+1} \equiv \left[\widehat{\mathbf{x}}_{e,t+1} \quad \widehat{\mathbf{x}}_{x,t+1}\right]'$ denotes the vector of state variables in log–deviations from steady state.

Second, I use the modified Blanchard and Kahn (1980) methodology suggested by Klein (2000) to solve the log–linear approximation of the model. This approach allows to express the model in state space form:

- *Measurement Equation*

$$\widehat{\mathbf{x}}_{c,t} = \mathbf{Z}\, \widehat{\mathbf{x}}_{s,t}$$

- *Transition Equation*

$$\widehat{\mathbf{x}}_{s,t} = \mathbf{T}\,\widehat{\mathbf{x}}_{s,t-1} + \mathbf{R}\mathbf{u}_t, \qquad \mathbf{u}_t \sim \mathcal{N}(\mathbf{0}, \boldsymbol{\Sigma})$$

  with

$$\mathbf{R} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\mathbf{u}_t = \begin{bmatrix} u_{z_s,t} \\ u_{z_c,t} \\ u_{\kappa,t} \\ u_{\epsilon,t} \end{bmatrix}$$

$$\boldsymbol{\Sigma} = \begin{bmatrix} \sigma_{z_s}^2 & 0 & 0 & 0 \\ 0 & \sigma_{z_c}^2 & 0 & 0 \\ 0 & 0 & \sigma_\kappa^2 & 0 \\ 0 & 0 & 0 & \sigma_\epsilon^2 \end{bmatrix}.$$

A.2 Steady State

This section derives the deterministic steady states for the pre– and post–deregulation economy.

A.2.1 Pre–Deregulation Economy

- I set $l = 0.3$.

- I normalise $z = 1$.

- I pin down the steady state loan interest rate r^b and capital ratio $\frac{k^B}{b}$.

- From (A.1), I derive

$$
\begin{aligned}
& & 1 &= \beta(1+r) \\
\Leftrightarrow & & r &= \frac{1}{\beta} - 1.
\end{aligned}
$$

- From equation (A.26)

$$
\begin{aligned}
& & y &= wl + n\pi^F \\
\overset{(A.10)}{\Longleftrightarrow} & & y &= wl + n\frac{1}{\phi}\frac{y}{n} \\
\Leftrightarrow & & y\left(1 - \frac{1}{\phi}\right) &= wl \\
\Leftrightarrow & & y &= \frac{\phi}{\phi - 1} wl. \qquad \text{(A.28)}
\end{aligned}
$$

- From (A.15) and the assumption that the borrowing constraint of entrepreneurs is binding in the deterministic long–run equilibrium, i.e. $\mu > 0$, I obtain

$$
\begin{aligned}
& & \kappa n^2 \pi^F &= b(1+r^b) \\
\overset{(A.10)}{\Longleftrightarrow} & & b &= \frac{\kappa}{1+r^b} n^2 \frac{1}{\phi}\frac{y}{n} \\
\overset{(A.28)}{\Longleftrightarrow} & & b &= \frac{\kappa}{(1+r^b)\phi}\frac{\phi}{\phi-1} wln \\
\Leftrightarrow & & b &= \frac{\kappa}{(1+r^b)(\phi-1)} wln. \qquad \text{(A.29)}
\end{aligned}
$$

- From (A.19), I derive θ_0 as

$$
\begin{aligned}
& & 2 &= \theta_0\theta_1(k^B)^{-1-\theta_1} + \frac{2+r-\delta^B}{1+r} \\
\overset{(A.1)}{\Longleftrightarrow} & & 2 - \beta(2+r-\delta^B) &= \theta_0\theta_1(k^B)^{-1-\theta_1} \\
\Leftrightarrow & & \theta_0 &= \left(2 - \beta(2+r-\delta^B)\right)\frac{(k^B)^{1+\theta_1}}{\theta_1}. \qquad \text{(A.30)}
\end{aligned}
$$

- From (A.23), I can calculate c^H:

$$
\begin{aligned}
& c^H = rd + a + wl \\
\overset{(A.21)}{\Longleftrightarrow} \quad & c^H = rd + \pi^B - \delta^B k^B + wl \\
\overset{(A.22)}{\Longleftrightarrow} \quad & c^H = rd + r^b b - rd - \Theta - \delta^B k^B + wl \\
\Leftrightarrow \quad & c^H = r^b b - \theta_0 \left(\frac{1}{k^B}\right)^{\theta_1} - \delta^B k^B + wl \\
\overset{(A.30)}{\Longleftrightarrow} \quad & c^H = r^b b - \frac{1}{\theta_1}\left(2 - \beta(2 + r - \delta^B)\right)(k^B)^{1+\theta_1-\theta_1} - \delta^B k^B + wl \\
\Leftrightarrow \quad & c^H = r^b b - \frac{1}{\theta_1}\left(2 - \beta(2 + r - \delta^B)\right)\frac{k^B}{b} b - \delta^B \frac{k^B}{b} b + wl \\
\Leftrightarrow \quad & c^H = \left[r^b - \frac{1}{\theta_1}\left(2 - \beta(2 + r - \delta^B)\right)\frac{k^B}{b} - \delta^B \frac{k^B}{b}\right] b + wl.
\end{aligned}
$$

$$
\overset{(A.29)}{\Longleftrightarrow} \quad c^H = \underbrace{\left[r^b - \left(\frac{1}{\theta_1}\left(2 - \beta(2 + r - \delta^B)\right) + \delta^B\right)\frac{k^B}{b}\right]\frac{\kappa}{(1 + r^b)(\phi - 1)}}_{\equiv const_A} wln + wl. \tag{A.31}
$$

- Using equations (A.3) and (A.31), I am now able to calculate a value for n:

$$
\begin{aligned}
& const_A wln + wl = (1 - l)w\frac{\xi}{1 - \xi} \\
\Leftrightarrow \quad & const_A ln = (1 - l)\frac{\xi}{1 - \xi} - l \\
\Leftrightarrow \quad & n = \left(\frac{\xi}{1 - \xi}\frac{1 - l}{l} - 1\right)\frac{1}{const_A}.
\end{aligned} \tag{A.32}
$$

- From equations (A.7) and (A.9), I derive the wage rate as

$$
\begin{aligned}
& \left(\frac{y}{k}\right)^{\frac{1}{\phi}} = \frac{\phi}{\phi - 1}\frac{w}{z} \\
\overset{(A.8)}{\Longleftrightarrow} \quad & \left(n^{\frac{\phi}{\phi-1}}\right)^{\frac{1}{\phi}} = \frac{\phi}{\phi - 1}\frac{w}{z} \\
\Leftrightarrow \quad & w = \frac{\phi - 1}{\phi} z n^{\frac{1}{\phi-1}}.
\end{aligned} \tag{A.33}
$$

- As a result, I can use equation (A.31) to calculate c^H, equation (A.28) to get y, and equation (A.29) to determine b.

- Since I know b and the capital ratio $\frac{k^B}{b}$, the bank capital stock can be easily computed by $k^B = \frac{k^B}{b} b$.

- From (A.20), I derive bank deposits as

$$d = b - k^B.$$

- Then, I use (A.30) to determine θ_0.

- From (A.18), I can derive the mean value of the elasticity of substitution in the credit market as

$$\begin{aligned} r^b &= \frac{\epsilon}{\epsilon - 1}\left[r + \frac{\theta_0\theta_1}{b(k^B)^{\theta_1}} r\right] \\ \Leftrightarrow \qquad r^b &= \epsilon\left[r^b - r - \frac{\theta_0\theta_1}{b(k^B)^{\theta_1}} r\right] \\ \Leftrightarrow \qquad \epsilon &= \frac{r^b}{r^b - r\left(1 + \frac{\theta_0\theta_1}{b(k^B)^{\theta_1}}\right)}. \end{aligned}$$

- From (A.16)

$$n_e = \delta n.$$

- From (A.10)

$$\pi^F = \frac{1}{\phi}\frac{y}{n}.$$

- From (A.8)

$$\begin{aligned} y &= n^{\frac{\phi}{\phi-1}} k \\ \Leftrightarrow \qquad k &= y n^{\frac{\phi}{1-\phi}}. \end{aligned}$$

- From (A.7)

$$p = \frac{\phi}{\phi - 1}\frac{w}{z}.$$

- From (A.22)

$$\pi^B = r^b b - rd - \theta_0 \left(\frac{1}{k^B}\right)^{\theta_1}.$$

- From (A.23)

$$a = c^H - rd - wl.$$

- From (A.2)

$$v = \frac{\beta}{1-\beta} a.$$

- From (A.13) and (A.14), together with (A.16), I can derive the number of entrepreneurs as

$$\frac{1}{1-\beta_E(1-\delta)}\left(\beta_E\left(\pi^F\left(1-\frac{1}{\mu_E}\right)+\frac{\chi}{2}\delta^2\right)+\beta_E\mu\kappa n\pi^F+\mu\kappa n\pi^F\left(1-\frac{1}{\mu_E}\right)\right)$$
$$= (c^E)^{-\gamma_E}(1+\chi\delta)$$

$$\Leftrightarrow \quad \beta_E\pi^F\left(1-\frac{1}{\mu_E}\right)+\beta_E\frac{\chi}{2}\delta^2+\beta_E(c^E)^{\gamma_E}\mu\kappa n\pi^F+(c^E)^{\gamma_E}\mu\kappa n\pi^F\left(1-\frac{1}{\mu_E}\right)$$
$$= (1-\beta_E(1-\delta))(1+\chi\delta)$$

$$\overset{(A.12)}{\Longleftrightarrow} \quad \pi^F\left(1-\frac{1}{\mu_E}\right)\left(\beta_E+\frac{1-\beta_E(1+r^b)}{1+r^b}\kappa n\right)$$
$$= (1-\beta_E(1-\delta))(1+\chi\delta)-\beta_E\frac{\chi}{2}\delta^2-\beta_E\frac{1-\beta_E(1+r^b)}{1+r^b}\kappa n\pi^F$$

$$\Leftrightarrow \quad \left(1-\frac{1}{\mu_E}\right)=\Bigg[(1-\beta_E(1-\delta))(1+\chi\delta)-\beta_E\frac{\chi}{2}\delta^2$$
$$-\beta_E\frac{1-\beta_E(1+r^b)}{1+r^b}\kappa n\pi^F\Bigg]\left(\pi^F\left(\beta_E+\frac{1-\beta_E(1+r^b)}{1+r^b}\kappa n\right)\right)^{-1}$$

$$\Leftrightarrow \quad \frac{1}{\mu_E} = 1-\Bigg[(1-\beta_E(1-\delta))(1+\chi\delta)-\beta_E\frac{\chi}{2}\delta^2$$
$$-\beta_E\frac{1-\beta_E(1+r^b)}{1+r^b}\kappa n\pi^F\Bigg]\left(\pi^F\left(\beta_E+\frac{1-\beta_E(1+r^b)}{1+r^b}\kappa n\right)\right)^{-1}$$

$$\Leftrightarrow \quad \frac{1}{\mu_E} = \left[\pi^F\left(\beta_E + \frac{1-\beta_E(1+r^b)}{1+r^b}\kappa n\right) - (1-\beta_E(1-\delta))(1+\chi\delta)\right.$$
$$\left. +\beta_E\frac{\chi}{2}\delta^2 + \beta_E\frac{1-\beta_E(1+r^b)}{1+r^b}\kappa n\pi^F\right]\left(\pi^F\left(\beta_E + \frac{1-\beta_E(1+r^b)}{1+r^b}\kappa n\right)\right)^{-1}$$

$$\Leftrightarrow \quad \mu_E = \frac{\pi^F\left(\beta_E + \frac{1-\beta_E(1+r^b)}{1+r^b}\kappa n\right)}{\beta_E\pi^F + (1+\beta_E)\frac{1-\beta_E(1+r^b)}{1+r^b}\kappa n\pi^F - (1-\beta_E(1-\delta))(1+\chi\delta) + \beta_E\frac{\chi}{2}\delta^2}.$$

- From (A.24) together with (A.16)

$$c^E = \frac{1}{\mu_E}\left(n\pi^F - n_e - r^b b - \frac{\chi}{2}\delta^2 n\right).$$

- From (A.12)

$$\mu = (c^E)^{-\gamma_E}\frac{1-\beta_E(1+r^b)}{1+r^b}.$$

- Finally, from (A.14) together with (A.16)

$$q = (c^E)^{-\gamma_E}(1+\chi\delta).$$

A.2.2 Post–Deregulation Economy

- As before, I normalise $z = 1$.
- Also, from (A.1) I can derive r as

$$r = \frac{1}{\beta} - 1.$$

- From (A.30), I can compute bank capital k^B as

$$k^B = \left(\frac{\theta_0\theta_1}{2-\beta(2+r-\delta^B)}\right)^{\frac{1}{1+\theta_1}}.$$

- The magnitude of the deregulation shock is determined by pinning down the bank capital ratio after deregulation $\frac{k^B}{b}$. Accordingly, bank assets b can be easily calculated by $b = \left(\frac{k^B}{b}\right)^{-1}k^B$.

- Then, I can use (A.20) to calculate bank deposits d.

The remainder of the problem cannot be solved analytically. I now show how I simplify the system before I approximate the solution.

- First, I use equation (A.29) to derive an expression for the gross loan interest rate:

$$(1+r^b) = \underbrace{\frac{\kappa}{b(\phi-1)}}_{\equiv const_B} wln. \tag{A.34}$$

- Second, I combine equations (A.13) and (A.14) to obtain another expression for the gross loan interest rate:

$$\frac{1}{1-\beta_E(1-\delta)}\left(\beta_E\left(\pi^F\left(1-\frac{1}{\mu_E}\right)+\frac{\chi}{2}\delta^2\right)+\beta_E\mu\kappa n\pi^F+\mu\kappa n\pi^F\left(1-\frac{1}{\mu_E}\right)\right)$$
$$= (c^E)^{-\gamma_E}(1+\chi\delta)$$

$$\Leftrightarrow \quad \beta_E\pi^F\left(1-\frac{1}{\mu_E}\right)+\beta_E\frac{\chi}{2}\delta^2+\beta_E(c^E)^{\gamma_E}\mu\kappa n\pi^F+(c^E)^{\gamma_E}\mu\kappa n\pi^F\left(1-\frac{1}{\mu_E}\right)$$
$$= (1-\beta_E(1-\delta))(1+\chi\delta)$$

$$\overset{(A.12)}{\Longleftrightarrow} \quad \pi^F\left(1-\frac{1}{\mu_E}\right)\left(\beta_E+\frac{1-\beta_E(1+r^b)}{1+r^b}\kappa n\right)+-\beta_E\frac{\chi}{2}\delta^2+\beta_E\frac{1-\beta_E(1+r^b)}{1+r^b}\kappa n\pi^F$$
$$= (1-\beta_E(1-\delta))(1+\chi\delta)$$

$$\overset{(A.15)}{\Longleftrightarrow} \quad \frac{(1+r^b)b}{\kappa n^2}\left(1-\frac{1}{\mu_E}\right)\left(\beta_E+\frac{1-\beta_E(1+r^b)}{1+r^b}\kappa n\right)+\beta_E\frac{\chi}{2}\delta^2$$
$$+\beta_E\frac{1-\beta_E(1+r^b)}{1+r^b}\kappa n\frac{(1+r^b)b}{\kappa n^2} = (1-\beta_E(1-\delta))(1+\chi\delta)$$

$$\Leftrightarrow \quad (1-\beta_E(1-\delta))(1+\chi\delta)-\beta_E\frac{\chi}{2}\delta^2 = \beta_E(1+r^b)\frac{b}{\kappa n^2}\left(1-\frac{1}{\mu_E}\right)$$
$$+\beta_E(1-\beta_E(1+r^b))\frac{b}{n}+(1-\beta_E(1+r^b))\frac{b}{n}\left(1-\frac{1}{\mu_E}\right)$$

$$\Leftrightarrow \quad (1-\beta_E(1-\delta))(1+\chi\delta) - \beta_E \frac{\chi}{2}\delta^2$$
$$= (1+r^b)\left[\beta_E \frac{b}{\kappa n^2}\left(1-\frac{1}{\mu_E}\right) - \beta_E^2 \frac{b}{n} - \beta_E \frac{b}{n}\left(1-\frac{1}{\mu_E}\right)\right] + \beta_E \frac{b}{n} + \frac{b}{n}\left(1-\frac{1}{\mu_E}\right)$$

$$\Leftrightarrow \quad \underbrace{(1-\beta_E(1-\delta))(1+\chi\delta) - \frac{\chi}{2}\delta^2\beta_E}_{\equiv const_C} - \left(\beta_E + 1 - \frac{1}{\mu_E}\right)\frac{b}{n}$$
$$= (1+r^b)\frac{b}{n}\beta_E\left[\frac{1}{\kappa n}\left(1-\frac{1}{\mu_E}\right) - \beta_E - 1 + \frac{1}{\mu_E}\right]$$

$$\Leftrightarrow \quad (1+r^b) = \frac{\frac{n}{b}const_C - \left(\beta_E + 1 - \frac{1}{\mu_E}\right)}{\beta_E\left[\frac{1}{\kappa n}\left(1-\frac{1}{\mu_E}\right) - \beta_E - 1 + \frac{1}{\mu_E}\right]}. \qquad \text{(A.35)}$$

- Third, I equalise consumption of private households from equations (A.3) and (A.31) to derive a condition for the portion of hours worked:

$$w(1-l)\frac{\xi}{1-\xi} = \underbrace{\left[r^b - \left(\frac{1}{\theta_1}\left(2-\beta(2+r-\delta^B)\right) + \delta^B\right)\frac{k^B}{b}\right]\frac{\kappa}{(1+r^b)(\phi-1)}}_{\equiv const_A} wln + wl$$

$$\Leftrightarrow \quad \frac{1-l}{l}\frac{\xi}{1-\xi} - 1 = \left[1 + r^b - 1 - \left(\frac{1}{\theta_1}\left(2-\beta(2+r-\delta^B)\right) + \delta^B\right)\frac{k^B}{b}\right]$$
$$\cdot \frac{\kappa}{(1+r^b)(\phi-1)}n$$

$$\overset{(A.34)}{\Longleftrightarrow} \quad \frac{1-l}{l}\frac{\xi}{1-\xi} - 1 = \frac{\kappa}{(\phi-1)}n$$
$$- \underbrace{\left[1 + \left(\frac{1}{\theta_1}\left(2-\beta(2+r-\delta^B)\right) + \delta^B\right)\frac{k^B}{b}\right]\frac{\kappa}{const_B(\phi-1)}}_{\equiv const_D}\frac{1}{wl}$$

$$\overset{(A.33)}{\Longleftrightarrow} \quad \frac{1-l}{l}\frac{\xi}{1-\xi} - 1 = \frac{\kappa}{(\phi-1)}n - const_D\frac{1}{l}\frac{\phi}{\phi-1}\frac{1}{z}n^{\frac{1}{1-\phi}}$$

$$\Leftrightarrow \quad \frac{\xi}{1-\xi} - \left(\frac{\xi}{1-\xi} + 1 + \frac{\kappa}{\phi-1}n\right) l = -const_D \frac{\phi}{\phi-1}\frac{1}{z} n^{\frac{1}{1-\phi}}$$

$$\Longleftrightarrow \qquad l = \frac{\frac{\xi}{1-\xi} + const_D \frac{\phi}{\phi-1}\frac{1}{z} n^{\frac{1}{1-\phi}}}{\frac{\xi}{1-\xi} + 1 + \frac{\kappa}{\phi-1}n}. \tag{A.36}$$

- Fourth, I combine equations (A.33), (A.34), and (A.35) to write l as a function of n

$$(1 + r^b) = const_B wln$$

$$\overset{(A.33)}{\Longleftrightarrow} \qquad const_B \frac{\phi-1}{\phi} z n^{\frac{\phi}{\phi-1}} l = (1 + r^b)$$

$$\overset{(A.35)}{\Longleftrightarrow} \qquad l = \frac{1}{const_B}\frac{1}{z}\frac{\phi}{\phi-1} n^{\frac{\phi}{\phi-1}} \frac{\frac{n}{b}const_C - \left(\beta_E + 1 - \frac{1}{\mu_E}\right)}{\beta_E\left[\frac{1}{\kappa n}\left(1 - \frac{1}{\mu_E}\right) - \beta_E - 1 + \frac{1}{\mu_E}\right]}. \tag{A.37}$$

- Conditions (A.36) and (A.2.2) form a system of two equations in two unknowns: l and n. Now, I can easily substitute for l, which yields a function $\mathbf{F}(n)$:

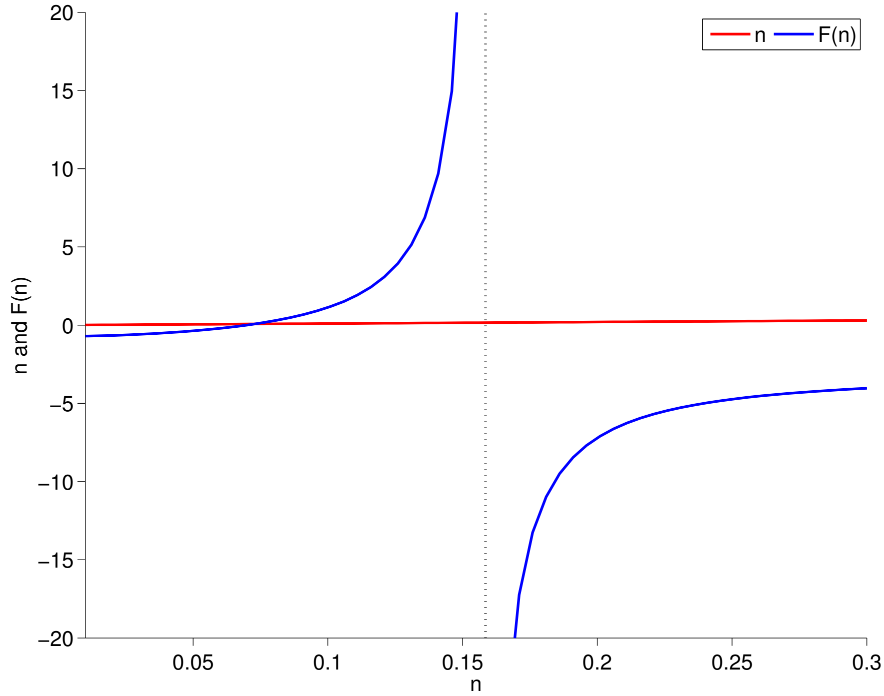
$$\frac{\frac{\xi}{1-\xi} + const_D \frac{\phi}{\phi-1}\frac{1}{z} n^{\frac{1}{1-\phi}}}{\frac{\xi}{1-\xi} + 1 + \frac{\kappa}{\phi-1}n} = \frac{1}{const_B}\frac{1}{z}\frac{\phi}{\phi-1} n^{\frac{\phi}{\phi-1}} \frac{\frac{n}{b}const_C - \left(\beta_E + 1 - \frac{1}{\mu_E}\right)}{\beta_E\left[\frac{1}{\kappa n}\left(1 - \frac{1}{\mu_E}\right) - \beta_E - 1 + \frac{1}{\mu_E}\right]}$$

$$\Leftrightarrow \quad \frac{\frac{\xi}{1-\xi} + const_D \frac{\phi}{\phi-1}\frac{1}{z} n^{\frac{1}{1-\phi}}}{\frac{1}{const_B}\frac{1}{z}\frac{\phi}{\phi-1} n^{\frac{\phi}{\phi-1}} \frac{\frac{n}{b}const_C - \left(\beta_E + 1 - \frac{1}{\mu_E}\right)}{\beta_E\left[\frac{1}{\kappa n}\left(1 - \frac{1}{\mu_E}\right) - \beta_E - 1 + \frac{1}{\mu_E}\right]}} = \frac{\xi}{1-\xi} + 1 + \frac{\kappa}{\phi-1}n$$

$$\Leftrightarrow \quad n = \left[\frac{\frac{\xi}{1-\xi} + const_D \frac{\phi}{\phi-1}\frac{1}{z} n^{\frac{1}{1-\phi}}}{\frac{1}{const_B}\frac{1}{z}\frac{\phi}{\phi-1} n^{\frac{\phi}{\phi-1}} \frac{\frac{n}{b}const_C - \left(\beta_E + 1 - \frac{1}{\mu_E}\right)}{\beta_E\left[\frac{1}{\kappa n}\left(1 - \frac{1}{\mu_E}\right) - \beta_E - 1 + \frac{1}{\mu_E}\right]}} - 1 - \frac{\xi}{1-\xi}\right]\frac{\phi-1}{\kappa} \equiv \mathbf{F}(n).$$

Figure A.1 displays function $\mathbf{F}(n)$ based on the calibration for the average state. $\mathbf{F}(n)$ is a function which maps the domain of n into itself. It intersects the 45 degree line exactly once. This intersection determines the fixed point in n, such that a unique solution for n exists.

Figure A.1: Fixed Point for n in the Average State



Since $\mathbf{F}(n)$ is highly non–linear in n, it is not possible to simply solve for n analytically with pencil and paper. Hence, I have to apply numerical methods in order to derive the steady state firm number n.

Once I have calculated n, it is easy to recover the solutions for the remaining variables.

- From (A.35), I obtain the loan interest rate

$$r^b = \frac{\frac{n}{b} const_C - \left(\beta_E + 1 - \frac{1}{\mu_E}\right)}{\beta_E \left[\frac{1}{\kappa n}\left(1 - \frac{1}{\mu_E}\right) - \beta_E - 1 + \frac{1}{\mu_E}\right]} - 1.$$

- I use equation (A.2.2) to calculate l.
- From equation (A.33), I get w.
- From equation (A.31), I calculate c^H.
- From equation (A.28), I calculate y.

- From (A.18), I derive the steady state elasticity of substitution in the credit market:

$$\epsilon = \frac{r^b}{r^b - r\left(1 + \frac{\theta_0\theta_1}{b(k^B)^{\theta_1}}\right)}.$$

- From (A.16), I calculate n_e.
- From (A.10), I get π^F.
- From (A.8), I compute k.
- From (A.7), I obtain p.
- From (A.22), I determine π^B.
- From (A.23), I calculate a.
- From (A.2), I calculate ν.
- From (A.24), I get c^E.
- From (A.12), I obtain μ.
- Finally, from (A.14), I compute q.

A.3 State–Specific Calibration

Table A.1 presents the state–specific calibration of parameters β, μ_E, θ_0, δ, and the values of ϵ before deregulation. These parameters are pinned down in order to match certain financial and operating figures of banks in each federal state. To be more precise, I set the parameters to obtain a capital ratio, loan interest rate, return on deposits, return on equity, and dividend payout ratio in the pre–deregulation steady state which is equal to the respective state average. Table A.2 lists the state average of these operating figures for the period between 1966 and the year in which intrastate branching through M&As was permitted. Numbers are calculated using aggregate commercial banking data taken from the HSOB provided by the FDIC.

Table A.1: State–Specific Calibration

		β	μ_E	θ_0	δ^B	ϵ
1	Alabama	0.9719	1.8069	1.51e-05	0.0874	1.5058
2	Alaska	0.9819	1.8399	1.44e-05	0.1287	1.2753
3	Arizona	0.9774	1.8629	9.79e-06	0.0768	1.4872
4	Arkansas	0.9614	1.7080	1.18e-05	0.0762	1.7512
5	California	0.9748	1.8746	1.05e-05	0.0701	1.5862
6	Colorado	0.9637	1.5176	3.02e-06	0.0223	1.5604
7	Connecticut	0.9768	1.7085	7.39e-06	0.0559	1.4078
8	Delaware	0.9874	1.9959	1.88e-05	0.0597	1.2329
9	District of Columbia	0.9844	2.0220	1.73e-05	0.0762	1.3119
10	Florida	0.9653	1.6585	8.30e-06	0.0718	1.6184
11	Georgia	0.9704	1.6485	8.83e-06	0.0786	1.4510
12	Hawaii	0.9603	1.6080	6.29e-06	0.0734	1.7106
13	Idaho	0.9809	1.9254	1.35e-05	0.0755	1.3887
14	Illinois	0.9549	1.7034	1.02e-05	0.0842	2.0480
15	Indiana	0.9595	1.6807	9.38e-06	0.0753	1.8279
16	Iowa	0.9587	1.6841	1.06e-05	0.0609	1.8612
17	Kansas	0.9617	1.6927	1.17e-05	0.0726	1.7151
18	Kentucky	0.9624	1.7380	1.31e-05	0.0859	1.7329
19	Louisiana	0.9626	1.7242	1.34e-05	0.1012	1.6619
20	Maine	0.9777	1.8220	1.27e-05	0.0648	1.4163
21	Maryland	0.9852	2.0905	2.14e-05	0.0811	1.2923
22	Massachusetts	0.9637	1.5744	5.39e-06	0.0591	1.5804
23	Michigan	0.9569	1.6513	6.93e-06	0.0625	1.9696
24	Minnesota	0.9576	1.6120	5.56e-06	0.0438	1.9045
25	Mississippi	0.9635	1.7096	1.16e-05	0.0891	1.6690
26	Missouri	0.9622	1.6504	8.17e-06	0.0620	1.7155
27	Montana	0.9588	1.5355	3.20e-06	0.0163	1.7518
28	Nebraska	0.9650	1.7076	1.20e-05	0.0821	1.6210
29	Nevada	0.9803	1.9359	1.62e-05	0.0833	1.3802
30	New Hampshire	0.9611	1.7100	1.20e-05	0.0750	1.7645
31	New Jersey	0.9762	1.8782	1.27e-05	0.0659	1.5142
32	New Mexico	0.9596	1.5911	6.39e-06	0.0634	1.6995
33	New York	0.9776	1.8325	9.73e-06	0.0549	1.4748
34	North Carolina	0.9815	1.9401	1.40e-05	0.0761	1.3760
35	North Dakota	0.9579	1.7034	1.16e-05	0.0790	1.8720
36	Ohio	0.9732	1.8767	1.55e-05	0.0701	1.5644
37	Oklahoma	0.9616	1.6718	1.07e-05	0.0891	1.6685
38	Oregon	0.9625	1.6337	6.39e-06	0.0721	1.7053
39	Pennsylvania	0.9651	1.7341	9.87e-06	0.0625	1.7569
40	Rhode Island	0.9776	2.0420	1.97e-05	0.0613	1.5368
41	South Carolina	0.9901	2.0001	1.92e-05	0.0779	1.1661
42	South Dakota	0.9802	2.0038	1.80e-05	0.0724	1.4215
43	Tennessee	0.9625	1.6540	8.32e-06	0.0690	1.6989
44	Texas	0.9614	1.6419	7.55e-06	0.0693	1.7293
45	Utah	0.9699	1.7183	9.52e-06	0.0848	1.5415
46	Vermont	0.9755	2.0263	1.66e-05	0.0597	1.6501
47	Virginia	0.9730	1.7717	1.05e-05	0.0662	1.5278
48	Washington	0.9622	1.5787	4.28e-06	0.0465	1.6810
49	West Virginia	0.9610	1.7922	1.68e-05	0.0783	1.8283
50	Wisconsin	0.9580	1.6758	8.99e-06	0.0673	1.9048
51	Wyoming	0.9609	1.5660	5.71e-06	0.0433	1.6476
	Mean	0.9684	1.7273	1.01e-05	0.0701	1.6062

Table A.2: State–Specific Financial and Operating Figures of Banks

		Captial Ratio	Loan Interest Rate	Return on Deposits	Return on Equity	Dividend Payout Ratio
1	Alabama	0.0782	0.0868	0.0289	0.1271	0.3120
2	Alaska	0.0617	0.0860	0.0184	0.1539	0.1638
3	Arizona	0.0562	0.0709	0.0231	0.1278	0.3989
4	Arkansas	0.0782	0.0943	0.0401	0.1161	0.3439
5	California	0.0596	0.0702	0.0258	0.1214	0.4227
6	Colorado	0.0710	0.1054	0.0377	0.1045	0.7865
7	Connecticut	0.0694	0.0826	0.0238	0.1083	0.4838
8	Delaware	0.0924	0.0682	0.0128	0.1337	0.5533
9	District of Columbia	0.0724	0.0669	0.0158	0.1277	0.4033
10	Florida	0.0701	0.0949	0.0360	0.1175	0.3892
11	Georgia	0.0745	0.0989	0.0305	0.1228	0.3599
12	Hawaii	0.0622	0.1001	0.0413	0.1345	0.4545
13	Idaho	0.0669	0.0701	0.0195	0.1248	0.3954
14	Illinois	0.0659	0.0930	0.0472	0.0994	0.1525
15	Indiana	0.0694	0.0939	0.0422	0.1159	0.3503
16	Iowa	0.0813	0.0939	0.0431	0.1150	0.4704
17	Kansas	0.0820	0.0963	0.0398	0.1150	0.3683
18	Kentucky	0.0765	0.0933	0.0391	0.1273	0.3254
19	Louisiana	0.0750	0.0984	0.0388	0.1063	0.0481
20	Maine	0.0792	0.0781	0.0228	0.1167	0.4444
21	Maryland	0.0765	0.0668	0.0150	0.1230	0.3405
22	Massachusetts	0.0673	0.1033	0.0377	0.1099	0.4619
23	Michigan	0.0626	0.0920	0.0450	0.1141	0.4526
24	Minnesota	0.0663	0.0938	0.0443	0.1109	0.6054
25	Mississippi	0.0731	0.0954	0.0379	0.1315	0.3225
26	Missouri	0.0734	0.0949	0.0393	0.1165	0.4682
27	Montana	0.0706	0.1006	0.0430	0.1150	0.8579
28	Nebraska	0.0785	0.0956	0.0363	0.1310	0.3731
29	Nevada	0.0720	0.0735	0.0201	0.1328	0.3726
30	New Hampshire	0.0795	0.0943	0.0405	0.1143	0.3441
31	New Jersey	0.0707	0.0723	0.0244	0.1188	0.4457
32	New Mexico	0.0692	0.1030	0.0421	0.1140	0.4438
33	New York	0.0686	0.0715	0.0229	0.1080	0.4914
34	North Carolina	0.0675	0.0696	0.0189	0.1175	0.3523
35	North Dakota	0.0757	0.0953	0.0440	0.1253	0.3692
36	Ohio	0.0789	0.0768	0.0275	0.1149	0.3897
37	Oklahoma	0.0742	0.1005	0.0399	0.0997	0.1068
38	Oregon	0.0601	0.0949	0.0390	0.1198	0.3979
39	Pennsylvania	0.0716	0.0846	0.0362	0.1159	0.4611
40	Rhode Island	0.0822	0.0660	0.0229	0.1150	0.4667
41	South Carolina	0.0828	0.0707	0.0100	0.1217	0.3599
42	South Dakota	0.0762	0.0686	0.0202	0.1148	0.3696
43	Tennessee	0.0709	0.0955	0.0390	0.1056	0.3464
44	Texas	0.0673	0.0960	0.0402	0.0980	0.2931
45	Utah	0.0652	0.0889	0.0310	0.1386	0.3881
46	Vermont	0.0736	0.0641	0.0251	0.0951	0.3722
47	Virginia	0.0720	0.0810	0.0278	0.1160	0.4297
48	Washington	0.0608	0.0975	0.0393	0.0969	0.5199
49	West Virginia	0.0863	0.0905	0.0406	0.1130	0.3074
50	Wisconsin	0.0703	0.0929	0.0438	0.1137	0.4080
51	Wyoming	0.0786	0.1042	0.0407	0.1108	0.6094
	Mean	0.0722	0.0870	0.0326	0.1174	0.4030

A.4 Banking Deregulation Dates

Table A.3 lists the years in which each federal state entered intra– and interstate banking. Dates are taken from Demyanyk *et al.* (2007) who updated the years of deregulation reported in Amel (1993) and Kroszner and Strahan (1999).

Table A.3: States and Year of Deregulation

		Intrastate Branching through M&A	Intrastate de novo Branching	Interstate Banking
1	Alabama (AL)	1981	1990	1987
2	Alaska (AK)	< 1970	< 1970	1982
3	Arizona (AZ)	<1970	< 1970	1986
4	Arkansas (AR)	1994	1999	1989
5	California (CA)	< 1970	< 1970	1987
6	Colorado (CO)	1991	1997	1988
7	Connecticut (CT)	1980	1988	1983
8	Delaware (DE)	< 1970	< 1970	1988
9	District of Colombia (DC)	< 1970	< 1970	1985
10	Florida (FL)	1988	1988	1985
11	Georgia (GA)	1983	1998	1985
12	Hawaii (HI)	1986	1986	1995
13	Idaho (ID)	< 1970	< 1970	1985
14	Illinois (IL)	1988	1993	1986
15	Indiana (IN)	1989	1991	1986
16	Iowa (IA)	1997	* * *	1991
17	Kansas (KS)	1987	1990	1992
18	Kentucky (KY)	1990	2001	1984
19	Louisiana (LA)	1988	1988	1987
20	Maine (ME)	1975	1975	1978
21	Maryland (MD)	< 1970	< 1970	1985
22	Massachusetts (MA)	1984	1984	1983
23	Michigan (MI)	1987	1988	1986
24	Minnesota (MN)	1993	* * *	1986
25	Mississippi (MS)	1986	1989	1988
26	Missouri (MO)	1990	1990	1986
27	Montana (MT)	1990	1997	1993
28	Nebraska (NE)	1985	* * *	1990
29	Nevada (NV)	< 1970	< 1970	1985
30	New Hampshire (NH)	1987	1987	1987
31	New Jersey (NJ)	1977	1996	1986
32	New Mexico (NM)	1991	1991	1989
33	New York (NY)	1976	* * *	1982
34	North Carolina (NC)	< 1970	< 1970	1985
35	North Dakota (ND)	1987	1996	1991
36	Ohio (OH)	1979	1989	1985
37	Oklahoma (OK)	1988	2000	1987
38	Oregon (OR)	1985	1985	1986
39	Pennsylvania (PA)	1982	1989	1986
40	Rhode Island (RI)	< 1970	< 1970	1984
41	South Carolina (SC)	< 1970	< 1970	1986
42	South Dakota (SD)	< 1970	< 1970	1988
43	Tennessee (TN)	1985	1990	1985
44	Texas (TX)	1988	1988	1987
45	Utah (UT)	1981	1981	1984
46	Vermont (VT)	1970	1970	1988
47	Virginia (VA)	1978	1986	1985
48	Washington (WA)	1985	1985	1987
49	West Virginia (WV)	1987	1987	1988
50	Wisconsin (WI)	1990	1989	1987
51	Wyoming (WY)	1988	1999	1987

Notes: * * * indicates that deregulation did not occur before 2001.

Appendix B

Appendix to "Business Cycles in Emerging Markets: the Role of Liability Dollarisation and Valuation Effects"

B.1 Model

This section describes the model environment of our framework with liability dollarisation.

B.1.1 Model Framework

The economy is represented by:

Production Technology

$Y_t = z_t K_t^{\alpha} (\Gamma_t l_t)^{1-\alpha}$ Production Function

$z_t = z_{t-1}^{\rho_z} \exp(\epsilon_t^z)$ Transitory Technology Process

$\Gamma_t = g_t \Gamma_{t-1} = \prod_{s=0}^{t} g_s, \quad g_t = \mu_g^{1-\rho_g} g_{t-1}^{\rho_g} \exp(\epsilon_t^g)$ Permanent Technology Process

$K_{t+1} = (1-\delta) K_t + I_t - \frac{\phi}{2} \left(\frac{K_{t+1}}{K_t} - \mu_g \right)^2 K_t$ Law of Motion of Capital

with $\epsilon_t^z \sim \mathcal{N}(0, \sigma_z^2)$ and $\epsilon_t^g \sim \mathcal{N}(0, \sigma_g^2)$.

Consumption

$$C_t = \left[\theta^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} + (1-\theta)^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} \qquad \text{Consumption Index}$$

$$u(C_t, 1-l_t) = \frac{[C_t^{\gamma}(1-l_t)^{1-\gamma}]^{1-\sigma}}{1-\sigma} \qquad \text{Household Period Utility Function}$$

$$c_t^{\star} = (c_{t-1}^{\star})^{\rho_c} \exp(\epsilon_t^c) \qquad \text{Foreign Consumption Process}$$

with $\epsilon_t^c \sim \mathcal{N}(0, \sigma_c^2)$.

Price Indices

$$e_t = \frac{p_t}{p_{F,t}} \qquad \text{Real Exchange Rate}$$

$$r_t = r + \psi\left(\exp\left(\mathrm{E}_t\left[\frac{p_{t+1}D_{t+1}}{e_{t+1}Y_{t+1}}\right] - \frac{pD}{eY}\right) - 1\right) \qquad \text{Interest Rate}$$

$$p_t = \left[\theta p_{H,t}^{1-\eta} + (1-\theta)p_{F,t}^{1-\eta}\right]^{\frac{1}{1-\eta}} \qquad \text{Domestic Price Index}$$

$$tot_t = \frac{p_{H,t}}{p_{F,t}} \qquad \text{Terms of Trade}$$

Aggregation

$$Y_t + p_t\frac{D_{t+1}}{e_t} = p_tC_t + I_t + p_t\frac{D_t}{e_t}(1 + r_{t-1}) \qquad \text{Resource Constraint}$$

$$NX_t = p_{H,t}C_{H,t}^{\star} - p_{F,t}C_{F,t} \qquad \text{Net Exports}$$

$$CA_t = -r_{t-1}p_t\frac{D_t}{e_t} + NX_t \qquad \text{Current Account}$$

$$\Delta NFA_t = CA_t + VAL_t \qquad \text{Change in Net Foreign Asset Position}$$

$$VAL_t = D_t\left(\frac{p_{t-1}}{e_{t-1}} - \frac{p_t}{e_t}\right) \qquad \text{Valuation Effects}$$

$$Y_t = p_{H,t}(C_{H,t} + C_{H,t}^{\star} + I_t) \qquad \text{Good Market Clearing}$$

Since there is no population growth in this model, the mass of population is set equal to one. Moreover, the home–produced good serves as numéraire, i.e. we normalise its price $p_{H,t}$ to one. Accordingly, everything is expressed in units of the home good instead of the domestic currency.

B.1.2 Detrending the Variables

The variables Y_t, C_t, $C_{H,t}$, $C_{F,t}$, I_t, K_t, and D_t as well as $C^\star_{H,t}$ and $C^\star_t$ exhibit a common stochastic trend.[1] They need to be detrended in order to obtain system of stationary variables. Consequently, the relevant variables are detrended in the following way:

$$x_t \equiv \frac{X_t}{\Gamma_{t-1}},$$

where x_t denotes the stationary counterpart of X_t. Hence, our relevant equations in detrended form are given by

- Production Function

$$y_t = \frac{Y_t}{\Gamma_{t-1}} = \frac{z_t K_t^\alpha (\Gamma_t l_t)^{1-\alpha}}{\Gamma_{t-1}} = z_t k_t^{1-\alpha}(g_t l_t)^\alpha$$

- Law of Motion of Capital

$$\begin{aligned} g_t k_{t+1} = \frac{\Gamma_t K_{t+1}}{\Gamma_t \Gamma_{t-1}} &= \frac{(1-\delta)K_t + I_t}{\Gamma_{t-1}} - \frac{\phi}{2}\left(\frac{K_{t+1}\Gamma_t}{\Gamma_t\Gamma_{t-1}}\frac{\Gamma_{t-1}}{K_t} - \mu_g\right)^2 \frac{K_t}{\Gamma_{t-1}} \\ &= (1-\delta)k_t + i_t - \frac{\phi}{2}\left(\frac{g_t k_{t+1}}{k_t} - \mu_g\right)^2 k_t \end{aligned}$$

- Utility Function

$$\begin{aligned} u(C_t, 1-l_t) = \frac{(C_t^\gamma(1-l_t)^{1-\gamma})^{1-\sigma}}{1-\sigma} &= \frac{\Gamma_{t-1}^{\gamma(1-\sigma)}}{\Gamma_{t-1}^{\gamma(1-\sigma)}} \frac{(C_t^\gamma(1-l_t)^{1-\gamma})^{1-\sigma}}{1-\sigma} \\ \Leftrightarrow \qquad &= \Gamma_{t-1}^{\gamma(1-\sigma)} \frac{\left(\left(\frac{C_t}{\Gamma_{t-1}}\right)^\gamma (1-l_t)^{1-\gamma}\right)^{1-\sigma}}{1-\sigma} \\ \Leftrightarrow \qquad &= \underbrace{\Gamma_{t-1}^{\gamma(1-\sigma)}}_{\equiv \kappa_{t-1}} \underbrace{\frac{(c_t^\gamma(1-l_t)^{1-\gamma})^{1-\sigma}}{1-\sigma}}_{u(c_t, 1-l_t)} \\ \Leftrightarrow \qquad &= \kappa_{t-1} u(c_t, 1-l_t) \end{aligned}$$

[1] In general, foreign and domestic variables can exhibit different stochastic trends. However, to keep the model tractable, we assume that domestic and foreign variables share a cointegrating relationship with cointegrating vector $\boldsymbol{\beta} = [1, -1]'$.

- Consumption Index

$$c_t = \frac{C_t}{\Gamma_{t-1}} = \frac{\left[\theta^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} + (1-\theta)^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}}{\Gamma_{t-1}}$$

$$c_t = \left[\theta^{\frac{1}{\eta}} \left(\frac{C_{H,t}}{\Gamma_{t-1}}\right)^{\frac{\eta-1}{\eta}} + (1-\theta)^{\frac{1}{\eta}} \left(\frac{C_{F,t}}{\Gamma_{t-1}}\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$$

$$c_t = \left[\theta^{\frac{1}{\eta}} c_{H,t}^{\frac{\eta-1}{\eta}} + (1-\theta)^{\frac{1}{\eta}} c_{F,t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}.$$

- Resource Constraint

$$y_t = \frac{Y_t}{\Gamma_{t-1}} = \frac{p_t C_t + I_t + p_t \frac{D_t}{e_t}(1+r_{t-1})}{\Gamma_{t-1}} - \frac{\Gamma_t p_t \frac{D_{t+1}}{e_t}}{\Gamma_{t-1}\Gamma_t} = p_t c_t + i_t + p_t \frac{d_t}{e_t}(1+r_{t-1}) - g_t p_t \frac{d_{t+1}}{e_t}$$

B.1.3 Maximisation Problem of the Household

The optimisation problem of the representative household can be decomposed into two stages. The first stage describes the *intratemporal* optimisation problem and derives optimal consumption of home and foreign goods. The second stage is the *intertemporal* optimisation problem, which determines the optimal intertemporal consumption and saving behaviour.

First Stage – Intratemporal Optimisation

The detrended consumption index is given by

$$c_t = \left[\theta^{\frac{1}{\eta}} c_{H,t}^{\frac{\eta-1}{\eta}} + (1-\theta)^{\frac{1}{\eta}} c_{F,t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}},$$

where $c_{H,t}$ denotes detrended consumption of the home good, $c_{F,t}$ denotes detrended consumption of the foreign good, $\theta \in (0,1)$ is the share of home goods in consumption, and $\eta \in (0,\infty)$ is the elasticity of intratemporal substitution between home and foreign goods.

The price index p_t is defined as the minimum expenditure required to buy one unit of the detrended composite good c_t, given the prices of the home and foreign goods. Accordingly, the representative agent solves the minimisation problem

$$\begin{aligned} \min_{\{c_{H,t},c_{F,t}\}} \quad & p_t c_t = p_{H,t} c_{H,t} + p_{F,t} c_{F,t} \\ \text{s.t.} \quad & c_t = \left[\theta^{\frac{1}{\eta}} c_{H,t}^{\frac{\eta-1}{\eta}} + (1-\theta)^{\frac{1}{\eta}} c_{F,t}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} = 1. \end{aligned}$$

We set up the Lagrangian

$$\mathcal{L} = p_{H,t} c_{H,t} + p_{F,t} c_{F,t} - p_t \left[c_t - 1 \right],$$

where we can use p_t as the Lagrange multiplier because it determines the shadow price of consumption. First–order conditions can then be derived as

$$\begin{aligned} \frac{\partial \mathcal{L}}{\partial c_{H,t}} = p_{H,t} - p_t \left(\frac{\eta}{\eta-1} \right) \left[\theta^{\frac{1}{\eta}} c_{H,t}^{\frac{\eta-1}{\eta}} + (1-\theta)^{\frac{1}{\eta}} c_{F,t}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}-1} \theta^{\frac{1}{\eta}} \left(\frac{\eta-1}{\eta} \right) c_{H,t}^{\frac{\eta-1}{\eta}-1} = 0 \\ \Leftrightarrow \qquad p_{H,t} = p_t c_t^{\frac{1}{\eta}} \theta^{\frac{1}{\eta}} c_{H,t}^{-\frac{1}{\eta}} \end{aligned}$$

and

$$\begin{aligned} \frac{\partial \mathcal{L}}{\partial c_{F,t}} = p_{F,t} - p_t \left(\frac{\eta}{\eta-1} \right) \left[\theta^{\frac{1}{\eta}} c_{H,t}^{\frac{\eta-1}{\eta}} + (1-\theta)^{\frac{1}{\eta}} c_{F,t}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}-1} (1-\theta)^{\frac{1}{\eta}} \left(\frac{\eta-1}{\eta} \right) c_{F,t}^{\frac{\eta-1}{\eta}-1} = 0 \\ \Leftrightarrow \qquad p_{F,t} = p_t c_t^{\frac{1}{\eta}} (1-\theta)^{\frac{1}{\eta}} c_{F,t}^{-\frac{1}{\eta}}. \end{aligned}$$

Hence, we get

$$\begin{aligned} c_{H,t} &= \theta \left(\frac{p_t}{p_{H,t}} \right)^{\eta} c_t, \\ c_{F,t} &= (1-\theta) \left(\frac{p_t}{p_{F,t}} \right)^{\eta} c_t. \end{aligned}$$

Note that we can combine and rearrange the above equations for $c_{H,t}$ and $c_{F,t}$ to obtain

$$\frac{c_{H,t}}{c_{F,t}} = \frac{\theta}{1-\theta} \left(\frac{p_{H,t}}{p_{F,t}} \right)^{-\eta}.$$

From this equation, we can easily show that the elasticity of intratemporal substitution between home and foreign consumption goods is given by η:

$$\frac{\mathrm{d}\ \log\left(\frac{c_{H,t}}{c_{F,t}}\right)}{\mathrm{d}\ \log\left(\frac{p_{H,t}}{p_{F,t}}\right)} = -\eta,$$

i.e. if the relative price of home consumption increases by 1 percent, relative home consumption declines by η percent.

As a next step, we derive the consumption price index p_t:

$$\begin{aligned}
& p_t c_t = p_{H,t} c_{H,t} + p_{F,t} c_{F,t} \\
\Leftrightarrow \quad & p_t c_t = p_{H,t} \theta \left(\frac{p_t}{p_{H,t}}\right)^{\eta} c_t + p_{F,t}(1-\theta)\left(\frac{p_t}{p_{F,t}}\right)^{\eta} c_t \\
\Leftrightarrow \quad & p_t = \theta p_t^{\eta} p_{H,t}^{1-\eta} + (1-\theta) p_t^{\eta} p_{F,t}^{1-\eta} \\
\Leftrightarrow \quad & p_t^{1-\eta} = \theta p_{H,t}^{1-\eta} + (1-\theta) p_{F,t}^{1-\eta} \\
\Leftrightarrow \quad & p_t = \left[\theta p_{H,t}^{1-\eta} + (1-\theta) p_{F,t}^{1-\eta}\right]^{\frac{1}{1-\eta}} .
\end{aligned}$$

Since we normalise the price of home goods to one, our equations determining the consumption of home goods and the price index simplify to

$$\begin{aligned}
c_{H,t} &= \theta p_t^{\eta} c_t, \\
p_t &= \left[\theta + (1-\theta) p_{F,t}^{1-\eta}\right]^{\frac{1}{1-\eta}} .
\end{aligned}$$

Second Stage – Intertemporal Optimisation

Combining the detrended versions of production, law of motion of capital, and the resource constraint yields the aggregate resource constraint of the economy as a function of capital, labour, consumption, and foreign debt. As a result, the representative household's optimisation problem at time t can be stated as

$$\begin{aligned}
&\max_{\{c_\tau, l_\tau, k_{\tau+1}, d_{\tau+1}\}} \mathrm{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} (\kappa_{\tau-1} u(c_\tau, 1-l_\tau)) \\
\text{s.t.} \quad & z_t k_t^{1-\alpha} (g_t l_t)^{\alpha} + (1-\delta) k_\tau + g_\tau p_\tau \frac{d_{\tau+1}}{e_\tau} \geq \\
& \qquad p_\tau c_\tau + g_\tau k_{\tau+1} + \frac{\phi}{2}\left(g_\tau \frac{k_{\tau+1}}{k_\tau} - \mu_g\right)^2 k_\tau + p_\tau \frac{d_\tau}{e_\tau}(1 + r_{\tau-1}),
\end{aligned}$$

taking as given k_t, d_t, as well as the transversality condition $\lim_{j\to\infty} \mathrm{E}_t\left[\prod_{s=0}^{j-2} \frac{d_{t+j}}{1+r_{t+s}}\right] = 0$. Accordingly, the optimisation problem yields the following Lagrangian:

$$\begin{aligned}\mathcal{L} =&\mathrm{E}_t\Bigg[\sum_{\tau=t}^{\infty} \beta^{\tau-t}\Bigg(\kappa_{\tau-1}u(c_\tau, 1-l_\tau) + \lambda_\tau\Bigg(z_t k_t^{1-\alpha}(g_t l_t)^\alpha + g_\tau p_\tau \frac{d_{\tau+1}}{e_\tau} + (1-\delta)k_\tau \\ &-p_\tau c_\tau - g_\tau k_{\tau+1} - \frac{\phi}{2}\left(g_\tau \frac{k_{\tau+1}}{k_\tau} - \mu_g\right)^2 k_\tau - p_\tau \frac{d_\tau}{e_\tau}(1+r_{\tau-1})\Bigg)\Bigg)\Bigg]\end{aligned}$$

with the following FOCs:

$$\begin{aligned}
\text{(I)} \quad & \frac{\partial \mathcal{L}}{\partial c_t} = \kappa_{t-1}\frac{\partial u(c_t, 1-l_t)}{\partial c_t} - \lambda_t p_t = 0 \\
\Leftrightarrow \quad & \kappa_{t-1}\frac{\partial u(c_t, 1-l_t)}{\partial c_t} = \lambda_t p_t \\
\Rightarrow \quad & \kappa_t \mathrm{E}_t\left[\frac{\partial u(c_{t+1}, 1-l_{t+1})}{\partial c_{t+1}}\right] = \mathrm{E}_t\left[\lambda_{t+1}p_{t+1}\right] \\
\text{(II)} \quad & \frac{\partial \mathcal{L}}{\partial l_t} = \kappa_{t-1}\frac{\partial u(c_t, 1-l_t)}{\partial l_t} + \lambda_t \frac{\partial y_t}{\partial l_t} = 0 \\
\Leftrightarrow \quad & -\kappa_{t-1}\frac{\partial u(c_t, 1-l_t)}{\partial l_t} = \lambda_t \frac{\partial y_t}{\partial l_t} \\
\text{(III)} \quad & \frac{\partial \mathcal{L}}{\partial k_{t+1}} = -\lambda_t\left[g_t\left(1+\phi\left(g_t\frac{k_{t+1}}{k_t} - \mu_g\right)\right)\right] + \mathrm{E}_t\Bigg[\beta\lambda_{t+1}\Bigg(\frac{\partial y_{t+1}}{\partial k_{t+1}} \\
& + (1-\delta) + \phi\left(g_{t+1}\frac{k_{t+2}}{k_{t+1}} - \mu_g\right)g_{t+1}\frac{k_{t+2}}{k_{t+1}} - \frac{\phi}{2}\left(g_{t+1}\frac{k_{t+2}}{k_{t+1}} - \mu_g\right)^2\Bigg)\Bigg] = 0 \\
\Leftrightarrow \quad & \lambda_t\left[g_t\left(1+\phi\left(g_t\frac{k_{t+1}}{k_t} - \mu_g\right)\right)\right] = \mathrm{E}_t\Bigg[\beta\lambda_{t+1}\Bigg(\frac{\partial y_{t+1}}{\partial k_{t+1}} \\
& + (1-\delta) + \phi\left(g_{t+1}\frac{k_{t+2}}{k_{t+1}} - \mu_g\right)g_{t+1}\frac{k_{t+2}}{k_{t+1}} - \frac{\phi}{2}\left(g_{t+1}\frac{k_{t+2}}{k_{t+1}} - \mu_g\right)^2\Bigg)\Bigg] \\
\text{(IV)} \quad & \frac{\partial \mathcal{L}}{\partial d_{t+1}} = \lambda_t g_t \frac{p_t}{e_t} - \beta\mathrm{E}_t\left[\lambda_{t+1}\frac{p_{t+1}}{e_{t+1}}(1+r_t)\right] = 0 \\
\Leftrightarrow \quad & \lambda_t g_t \frac{p_t}{e_t} = \beta\mathrm{E}_t\left[\lambda_{t+1}\frac{p_{t+1}}{e_{t+1}}(1+r_t)\right] \\
\text{(V)} \quad & \frac{\partial \mathcal{L}}{\partial \lambda_t} = y_t + (1-\delta)k_t + p_t\frac{g_t d_{t+1}}{e_t} \\
& - c_t - g_t k_{t+1} - \frac{\phi}{2}\left(g_t\frac{k_{t+1}}{k_t} - \mu_g\right)^2 k_t - p_t\frac{d_t}{e_t}(1+r_{t-1}) = 0 \\
\Leftrightarrow \quad & y_t + (1-\delta)k_t + p_t\frac{g_t d_{t+1}}{e_t} = \\
& p_t c_t + g_t k_{t+1} + \frac{\phi}{2}\left(g_t\frac{k_{t+1}}{k_t} - \mu_g\right)^2 k_t + p_t\frac{d_t}{e_t}(1+r_{t-1})
\end{aligned}$$

B.1.4 International Prices and Trade

The representative agent's problem in the rest of the world (ROW) is analogous to the home country. However, the domestic economy is infinitesimally small. That is, the ROW is approximately closed and only consumes goods produced abroad. Accordingly, the price index of the foreign consumption composite $p_t^\star$ boils down to the foreign price of goods produced in the ROW $p_{F,t}^\star$, i.e. $p_t^\star = p_{F,t}^\star$. We assume that the law of one price holds:

$$p_{F,t} = \frac{p_{F,t}^\star}{s_t} = \frac{p_t^\star}{s_t},$$

and

$$p_{H,t} = \frac{p_{H,t}^\star}{s_t},$$

where s_t represents the nominal exchange rate defined as the price of the domestic currency in terms of the foreign currency. Since the domestic price of home goods is normalised to one, the nominal exchange rate simply equals the foreign price of home goods $p_{H,t}^\star$. The real exchange rate is the price of the domestic composite consumption good in units of the foreign composite consumption good:[2]

$$e_t = \frac{p_t s_t}{p_t^\star} = \frac{p_t s_t}{p_{F,t}^\star} = \frac{p_t s_t}{p_{F,t} s_t} = \frac{p_t}{p_{F,t}}.$$

Moreover, terms of trade are defined as the price of home–produced goods in terms of imported foreign goods:

$$tot_t = \frac{p_{H,t}}{p_{F,t}} = \frac{1}{p_{F,t}}.$$

Let $c_t^\star$ denote detrended foreign consumption. We assume that the ROW has the same composite consumption index as the domestic economy. Hence, from

[2]Despite the assumption that the law of one price holds for our individual goods, purchasing power parity is not fulfilled. Thus, the real exchange rate is not equal to one in our setup. At first glance, this seems somewhat bewildering. However, note that the home country is infinitesimally small from the viewpoint of the ROW, such that foreign composite consumption consists only of foreign goods. Therefore, we generally have $p_t s_t \neq p_t^\star$ and $e_t \neq 1$. Monacelli (2005) calls this the "law of one price gap".

the perspective of the home economy, foreign demand for the home good is

$$
\begin{aligned}
& c^{\star}_{H,t} = \theta^{\star}\left(\frac{p^{\star}_{t}}{p^{\star}_{H,t}}\right)^{\eta^{\star}} c^{\star}_{t} \\
\Leftrightarrow \quad & c^{\star}_{H,t} = \theta^{\star}\left(\frac{p^{\star}_{F,t}}{p^{\star}_{H,t}}\right)^{\eta^{\star}} c^{\star}_{t} \\
\Leftrightarrow \quad & c^{\star}_{H,t} = \theta^{\star}\left(\frac{p_{F,t}s_t}{p_{H,t}s_t}\right)^{\eta^{\star}} c^{\star}_{t} \\
\Leftrightarrow \quad & c^{\star}_{H,t} = \theta^{\star}\left(\frac{p_{F,t}}{p_{H,t}}\right)^{\eta^{\star}} c^{\star}_{t} \\
\Leftrightarrow \quad & c^{\star}_{H,t} = \theta^{\star}\left(\frac{1}{tot_t}\right)^{\eta^{\star}} c^{\star}_{t} \\
\Leftrightarrow \quad & c^{\star}_{H,t} = \theta^{\star} p_{F,t}^{\eta^{\star}} c^{\star}_{t}.
\end{aligned}
$$

Imports are given by $p_{F,t}c_{F,t}$, such that net exports can be calculated as

$$nx_t = p_{H,t}c^{\star}_{H,t} - p_{F,t}c_{F,t} = c^{\star}_{H,t} - p_{F,t}c_{F,t}.$$

B.1.5 Current Account and Valuation Effects

The change in the net foreign asset position equals the current account adjusted for valuation effects:

$$\Delta NFA_t = CA_t + VAL_t.$$

It is straightforward to derive valuation effects in this model. The current account is equal to the sum of negative interest payments on foreign debt and net exports:

$$CA_t = -r_{t-1}p_t\frac{D_t}{e_t} + NX_t.$$

Also, recall that the aggregate resource constraint given by

$$Y_t + p_t\frac{D_{t+1}}{e_t} = p_tC_t + I_t + p_t\frac{D_t}{e_t}(1 + r_{t-1}).$$

We can then rearrange the resource constraint to get

$$
\begin{aligned}
& Y_t - p_t C_t - I_t - r_{t-1} p_t \frac{D_t}{e_t} = p_t \left(-\frac{D_{t+1}}{e_t} + \frac{D_t}{e_t} \right) \\
\Leftrightarrow \quad & \underbrace{Y_t - p_t C_t - I_t}_{=\text{ Primary Current Account}} - r_{t-1} p_t \frac{D_t}{e_t} = -p_t \frac{D_{t+1}}{e_t} + p_t \frac{D_t}{e_t} - p_{t-1} \frac{D_t}{e_{t-1}} + p_{t-1} \frac{D_t}{e_{t-1}} \\
\Leftrightarrow \quad & \underbrace{Y_t - I_t}_{=\text{ Net Output}} \underbrace{- p_{H,t} C_{H,t} - p_{F,t} C_{F,t}}_{=-p_t C_t} - r_{t-1} p_t \frac{D_t}{e_t} = \underbrace{-p_t \frac{D_{t+1}}{e_t} + p_{t-1} \frac{D_t}{e_{t-1}}}_{=\Delta NFA_t} + p_t \frac{D_t}{e_t} - p_{t-1} \frac{D_t}{e_{t-1}} \\
\Leftrightarrow \quad & \underbrace{p_{H,t} C^{\star}_{H,t} + p_{H,t} C_{H,t} + I_t}_{=Y_t \text{ by good market equilibrium}} - I_t - p_{H,t} C_{H,t} - p_{F,t} C_{F,t} - r_{t-1} p_t \frac{D_t}{e_t} \\
& = \Delta NFA_t + p_t \frac{D_t}{e_t} - p_{t-1} \frac{D_t}{e_{t-1}} \\
\Leftrightarrow \quad & \Delta NFA_t = \underbrace{p_{H,t} C^{\star}_{H,t} - p_{F,t} C_{F,t}}_{=NX_t} - r_{t-1} p_t \frac{D_t}{e_t} - p_t \frac{D_t}{e_t} + p_{t-1} \frac{D_t}{e_{t-1}} \\
\Leftrightarrow \quad & \Delta NFA_t = NX_t - r_{t-1} p_t \frac{D_t}{e_t} + \underbrace{D_t \left(\frac{p_{t-1}}{e_{t-1}} - \frac{p_t}{e_t} \right)}_{=VAL_t} \\
\Leftrightarrow \quad & \Delta NFA_t = CA_t + VAL_t.
\end{aligned}
$$

Hence, valuation effects are given by

$$
VAL_t = D_t \left(\frac{p_{t-1}}{e_{t-1}} - \frac{p_t}{e_t} \right).
$$

Next, we take a look at the current account, net foreign asset position, and valuation effects in stationary form. Let us first consider the current account:

$$
\begin{aligned}
& ca_t = \frac{CA_t}{\Gamma_{t-1}} = -r_{t-1} p_t \frac{D_t}{\Gamma_{t-1} e_t} + \frac{NX_t}{\Gamma_{t-1}} \\
\Leftrightarrow \quad & ca_t = -r_{t-1} p_t \frac{d_t}{e_t} + p_{H,t} \frac{C^{\star}_{H,t} \Gamma^{\star}_{t-1}}{\Gamma_{t-1} \Gamma^{\star}_{t-1}} - p_{F,t} \frac{C_{F,t}}{\Gamma_{t-1}} \\
\Leftrightarrow \quad & ca_t = -r_{t-1} p_t \frac{d_t}{e_t} + p_{H,t} \frac{C^{\star}_{H,t} \Gamma^{\star}_{t-1}}{\Gamma_{t-1} \Gamma^{\star}_{t-1}} - p_{F,t} c_{F,t} \\
\Leftrightarrow \quad & ca_t = -r_{t-1} p_t \frac{d_t}{e_t} + p_{H,t} c^{\star}_{H,t} \underbrace{\frac{\Gamma^{\star}_{t-1}}{\Gamma_{t-1}}}_{=1} - p_{F,t} c_{F,t}
\end{aligned}
$$

$$\Leftrightarrow \qquad ca_t = -r_{t-1} p_t \frac{d_t}{e_t} + p_{H,t} c^{\star}_{H,t} - p_{F,t} c_{F,t}$$

$$\Leftrightarrow \qquad ca_t = -r_{t-1} p_t \frac{d_t}{e_t} + nx_t,$$

where we use the assumption that both the domestic small open economy and the ROW share a common stochastic trend component: $\Gamma_{t-1} = \Gamma^{\star}_{t-1}$. The stationary expression for the change in the net foreign asset position is given by

$$\frac{\Delta NFA_t}{\Gamma_{t-1}} = -\frac{D_{t+1}}{\Gamma_t} \frac{\Gamma_t}{\Gamma_{t-1}} \frac{p_t}{e_t} + \frac{D_t}{\Gamma_{t-1}} \frac{p_{t-1}}{e_{t-1}}$$

$$\Delta nfa_t = -g_t p_t \frac{d_{t+1}}{e_t} + p_{t-1} \frac{d_t}{e_{t-1}}.$$

Finally, detrended valuation effects can be derived as

$$\frac{VAL_t}{\Gamma_{t-1}} = \frac{D_t}{\Gamma_{t-1}} \left(\frac{p_{t-1}}{e_{t-1}} - \frac{p_t}{e_t} \right)$$

$$val_t = d_t \left(\frac{p_{t-1}}{e_{t-1}} - \frac{p_t}{e_t} \right).$$

B.1.6 Model Summary

Eventually, we can summarise our model, which is described by the following optimality and necessary conditions:

- Production Function

$$y_t = z_t k_t^{\alpha} (g_t l_t)^{1-\alpha} \tag{B.1}$$

- Period t Resource Constraint

$$y_t = p_t c_t + i_t + p_t \frac{d_t}{e_t}(1 + r_{t-1}) - p_t \frac{g_t d_{t+1}}{e_t} \tag{B.2}$$

- Law of Motion of Capital

$$g_t k_{t+1} = (1-\delta) k_t + i_t - \frac{\phi}{2} \left(\frac{g_t k_{t+1}}{k_t} - \mu_g \right)^2 k_t \tag{B.3}$$

- Investment Euler Equation

$$\frac{\partial u(c_t,1-l_t)}{\partial c_t}\left(1+\phi\left(g_t\frac{k_{t+1}}{k_t}-\mu_g\right)\right)=g_t^{\gamma(1-\sigma)-1}\beta \mathrm{E}_t\Bigg[\frac{p_t}{p_{t+1}}\frac{\partial u(c_{t+1},1-l_{t+1})}{\partial c_{t+1}}$$
$$\left(\frac{\partial y_{t+1}}{\partial k_{t+1}}+(1-\delta)+\phi\left(g_{t+1}\frac{k_{t+2}}{k_{t+1}}-\mu_g\right)g_{t+1}\frac{k_{t+2}}{k_{t+1}}-\frac{\phi}{2}\left(g_{t+1}\frac{k_{t+2}}{k_{t+1}}-\mu_g\right)^2\right)\Bigg] \tag{B.4}$$

- Labour–Leisure Trade–off

$$-p_t\frac{\partial u(c_t,1-l_t)}{\partial l_t}=\frac{\partial u(c_t,1-l_t)}{\partial c_t}\frac{\partial y_t}{\partial l_t} \tag{B.5}$$

- Bond Euler Equation

$$\frac{\partial u(c_t,l_t)}{\partial c_t}=g_t^{\gamma(1-\sigma)-1}\beta \mathrm{E}_t\left[\frac{\partial u(c_{t+1},l_{t+1})}{\partial c_{t+1}}\frac{e_t}{e_{t+1}}(1+r_t)\right] \tag{B.6}$$

- Interest Rate

$$r_t=r+\psi\left(\exp\left(\mathrm{E}_t\left[\frac{p_{t+1}d_{t+1}}{e_{t+1}y_{t+1}}\right]-\frac{pd}{ey}\right)-1\right) \tag{B.7}$$

- Consumption of the Home Good

$$c_{H,t}=\theta p_t^{\eta}c_t \tag{B.8}$$

- Consumption of the Foreign Good

$$c_{F,t}=(1-\theta)\left(\frac{p_t}{p_{F,t}}\right)^{\eta}c_t \tag{B.9}$$

- Price of Consumption

$$p_t=\left[\theta+(1-\theta)p_{F,t}^{1-\eta}\right]^{\frac{1}{1-\eta}} \tag{B.10}$$

- Exchange Rate

$$e_t=\frac{p_t}{p_{F,t}} \tag{B.11}$$

- Exports of Home Goods

$$c^{\star}_{H,t} = \theta^{\star} p^{\eta^{\star}}_{F,t} c^{\star}_t \tag{B.12}$$

- Good Market Clearing

$$y_t = c^{\star}_{H,t} + c_{H,t} + i_t \tag{B.13}$$

- Net Exports

$$nx_t = c^{\star}_{H,t} - p_{F,t} c_{F,t} \tag{B.14}$$

- Current Account

$$ca_t = -r_{t-1} p_t \frac{d_t}{e_t} + c^{\star}_{H,t} - p_{F,t} c_{F,t} \tag{B.15}$$

- Change in NFA

$$\Delta nfa_t = -g_t p_t \frac{d_{t+1}}{e_t} + p_{t-1} \frac{d_t}{e_{t-1}} \tag{B.16}$$

- Valuation Effects

$$val_t = d_t \left(\frac{p_{t-1}}{e_{t-1}} - \frac{p_t}{e_t} \right) = \Delta nfa_t - ca_t \tag{B.17}$$

- Transitory Technology Process

$$z_t = z^{\rho_z}_{t-1} \exp(\epsilon^z_t) \tag{B.18}$$

- Permanent Technology Process

$$g_t = \mu_g^{1-\rho_g} g^{\rho_g}_{t-1} \exp(\epsilon^g_t) \tag{B.19}$$

- Foreign Consumption Process

$$c^{\star}_t = (c^{\star}_{t-1})^{\rho_c} \exp(\epsilon^c_t) \tag{B.20}$$

Moreover, note that

$$\frac{\partial u(c_t, 1 - l_t)}{\partial c_t} = \frac{\gamma (c_t^{\gamma} (1 - l_t)^{1-\gamma})^{1-\sigma}}{c_t}$$

$$\frac{\partial u(c_t, 1-l_t)}{\partial l_t} = -\frac{(1-\gamma)(c_t^{\gamma}(1-l_t)^{1-\gamma})^{1-\sigma}}{(1-l_t)}$$
$$\frac{\partial y_t}{\partial k_t} = \alpha \frac{y_t}{k_t}$$
$$\frac{\partial y_t}{\partial l_t} = (1-\alpha)\frac{y_t}{l_t}$$

Steady States

We now turn to the derivation of the deterministic steady state.

- From (B.18), $z = 1$.
- From (B.19), $g = \mu_g$.
- From (B.20), $c^{\star} = 1$.
- From (B.6), $r = \mu_g^{1-\gamma(1-\sigma)}\frac{1}{\beta} - 1$.
- From (B.4) and (B.6):

$$\mu_g^{\gamma(1-\delta)-1}\beta\left(\alpha\frac{y}{k} + 1 - \delta\right) = \mu_g^{\gamma(1-\delta)-1}\beta(1+r)$$
$$\alpha\frac{y}{k} + 1 - \delta = 1 + r$$
$$\frac{k}{y} = \frac{\alpha}{r+\delta}.$$

- From (B.3)

$$i = \left(\mu_g - 1 + \delta\right)k. \tag{*}$$

- From (B.2) using (*)

$$y = pc + i + (1 + r - \mu_g)\frac{pd}{e}$$
$$y = pc + \left(\mu_g - 1 + \delta\right)k + (1 + r - \mu_g)\frac{pd}{e}$$
$$\frac{pc}{y} = 1 + \left(1 - \delta - \mu_g\right)\frac{k}{y} + (\mu_g - 1 - r)\frac{pd}{ey}.$$

- From (B.5)

$$\frac{1-\gamma}{\gamma}\frac{pc}{1-l} = (1-\alpha)\frac{y}{l}$$
$$\frac{pc}{y} = (1-\alpha)\frac{\gamma}{1-\gamma}\frac{1-l}{l}$$
$$l = (1-\alpha)\frac{\gamma}{1-\gamma}\left(\frac{pc}{y} + (1-\alpha)\frac{\gamma}{1-\gamma}\right)^{-1}$$

or, equivalently

$$\gamma = \frac{pc}{y}\left((1-\alpha)\frac{1-l}{l} + \frac{pc}{y}\right)^{-1}.$$

- From (B.1)

$$y = zk^{\alpha}\left(\mu_g l\right)^{1-\alpha}$$
$$\frac{y}{k} = zk^{\alpha-1}\left(\mu_g l\right)^{1-\alpha}$$
$$k = \left(\frac{k}{y}\right)^{\frac{1}{1-\alpha}} \mu_g l z^{\frac{1}{1-\alpha}}.$$

- Accordingly, we get $y = \frac{y}{k}k$, $\frac{pd}{e} = \frac{pd}{ey}y$, and $pc = \frac{pc}{y}y$.

- From (*), we can determine i.

- From (B.16)

$$\Delta nfa = \frac{pd}{e}\left(1-\mu_g\right).$$

- From (B.17)

$$val = 0.$$

- From (B.15)

$$ca = \Delta nfa.$$

- From (B.14) and (B.15)

$$nx = ca + r\frac{pd}{e}.$$

- From (B.9) and (B.10), we can determine

$$p_F c_F = \left[\theta p_F^{\eta-1} + (1-\theta)\right]^{-1} (1-\theta) pc.$$

Then we can insert this expression together with (B.12) in equation (B.14) to derive a function of p_F:

$$(1-\theta)(nx + pc) = \left[\theta\theta^\star c^\star p_F^{\eta^\star} + (1-\theta)\theta^\star c^\star p_F^{\eta^\star - \eta - 1} - \theta nx\right] p_F^{\eta-1}.$$

Unless $\eta = \eta^\star = 1$, this function cannot be solved for p_F analytically with pencil and paper. However, we can apply numerical methods to obtain p_F.

- From (B.10)

$$p = \left[\theta + (1-\theta) p_F^{1-\eta}\right]^{\frac{1}{1-\eta}}$$

- Then we can determine c as $c = \frac{pc}{p}$.
- From (B.12)

$$c_H^\star = \theta^\star p_F^{\eta^\star} c^\star$$

- From (B.8)

$$c_H = \theta p^\eta c$$

- From (B.9)

$$c_F = (1-\theta)\left(\frac{p}{p_F}\right)^\eta c$$

- From (B.11)

$$e = \frac{p}{p_F}$$

- Finally, we have $d = \frac{pd}{e}\frac{e}{p}$.

B.2 Solving the Model

Finally, we end up with a stationary system of 20 non–linear difference equations (B.1) – (B.20) in 20 variables. The model features 3 exogenous state variables, 2 endogenous state variables, and 15 control variables:

- Vector of exogenous state variables:
  $\mathbf{x}_{x,t} = \begin{bmatrix} z_t & g_t & c_t^\star \end{bmatrix}'$

- Vector of endogenous state variables:
  $\mathbf{x}_{e,t} = \begin{bmatrix} k_t & d_t \end{bmatrix}'$

- Vector of control variables:
  $\mathbf{x}_{c,t} = \begin{bmatrix} y_t & c_t & r_t & e_t & i_t & l_t & c_{H,t} & c_{F,t} & c_{H,t}^\star & p_t & p_{F,t} & nx_t & ca_t & \Delta nfa_t & val_t \end{bmatrix}'$.

Unfortunately, the model does not have a closed form solution. Therefore, we have to approximate its solution. We do so by log–linearising the system around its deterministic steady state. The technique of log–linearisation is described in Appendix A Section A.1.6.

Applying this method to the optimality and necessary conditions in the model at hand yields:

- Production Function

$$\widehat{y_t} = \widehat{z_t} + \alpha\widehat{k_t} + (1-\alpha)\widehat{g_t} + (1-\alpha)\widehat{l_t}$$

- Period t Resource Constraint

$$\begin{aligned}\widehat{y_t} = \frac{pc}{y}(\widehat{p_t} + \widehat{c_t}) + \frac{i}{y}\widehat{i_t} + \frac{pd}{ey}(1+r)\left(\widehat{d_t} + \widehat{p_t} - \widehat{e_t}\right) \\ + \frac{pd}{ey}r\widehat{r_{t-1}} + \frac{pd}{ey}\mu_g\left(\widehat{g_t} + \mathrm{E}_t\left[\widehat{d_{t+1}}\right] + \widehat{p_t} - \widehat{e_t}\right)\end{aligned}$$

- Law of Motion of Capital

$$\widehat{g_t} + \mathrm{E}_t\left[\widehat{k_{t+1}}\right] = \frac{1-\delta}{\mu_g}\widehat{k_t} + \frac{i}{\mu_g k}\widehat{i_t}$$

- Labour–Leisure Trade–off

$$\widehat{y_t} = \widehat{p_t} + \widehat{c_t} + \frac{1}{1-l}\widehat{l_t}$$

- Investment Euler Equation

$$(\gamma(1-\sigma)-1)\widehat{c_t}-(1-\gamma)(1-\sigma)\widehat{l_t}+\phi\mu_g\left(\widehat{g_t}+\mathrm{E}_t[\widehat{k_{t+1}}]-\widehat{k_t}\right)=\mu_g^{\gamma(1-\sigma)-1}\beta\cdot$$
$$\Bigg[\left(\alpha\frac{y}{k}+1-\delta\right)\Big((\gamma(1-\sigma)-1)\widehat{g_t}+\widehat{p_t}-\widehat{p_{t+1}}+(\gamma(1-\sigma)-1)\mathrm{E}_t[\widehat{c_{t+1}}]-$$
$$(1-\gamma)(1-\sigma)\mathrm{E}_t[\widehat{l_{t+1}}]\Big)+\alpha\frac{y}{k}\Big(\mathrm{E}_t[\widehat{y_{t+1}}]-\mathrm{E}_t[\widehat{k_{t+1}}]\Big)$$
$$+\mu_g^2\phi\Big(\mathrm{E}_t[\widehat{g_{t+1}}]+\mathrm{E}_t[\widehat{k_{t+2}}]-\mathrm{E}_t[\widehat{k_{t+1}}]\Big)\Bigg]$$

- Bond Euler Equation

$$\beta\mu_g^{\gamma(1-\sigma)-1}(1+r)\left((\gamma(1-\sigma)-1)\widehat{g_t}+\widehat{e_t}-\mathrm{E}_t[\widehat{e_{t+1}}]+\frac{r}{1+r}\widehat{r_t}\right)$$
$$=(1-(1-\sigma)\gamma)\left(\mathrm{E}_t[\widehat{c_{t+1}}]-\widehat{c_t}\right)+\frac{l}{1-l}\left(\frac{1}{1-l}\mathrm{E}_t[\widehat{l_{t+1}}]-\widehat{l_t}\right)$$

- Interest Rate

$$\widehat{r_t}=\frac{\psi}{r}\frac{pd}{ey}\left[\mathrm{E}_t[\widehat{d_{t+1}}]+\mathrm{E}_t[\widehat{p_{t+1}}]-\mathrm{E}_t[\widehat{y_{t+1}}]-\mathrm{E}_t[\widehat{e_{t+1}}]\right]$$

- Consumption of the Home Good

$$\widehat{c_{H,t}}=\eta\widehat{p_t}+\widehat{c_t}$$

- Consumption of the Foreign Good

$$\widehat{c_{F,t}}=\eta\left(\widehat{p_t}-\widehat{p_{F,t}}\right)+\widehat{c_t}$$

- Price of Consumption

$$\widehat{p_t}=\frac{(1-\theta)p_F^{1-\eta}}{\theta+(1-\theta)p_F^{1-\eta}}\widehat{p_{F,t}}$$

- Exchange Rate

$$\widehat{e_t}=\widehat{p_t}-\widehat{p_{F,t}}$$

- Exports of Home Goods

$$\widehat{c_{H,t}^{\star}}=\eta^{\star}\widehat{p_{F,t}}+\widehat{c_t^{\star}}$$

- Good Market Clearing

$$\widehat{y_t} = \frac{c_H^\star}{y}\widehat{c_{H,t}^\star} + \frac{c_H}{y}\widehat{c_{H,t}} + \frac{i}{y}\widehat{i_t}$$

- Net Exports

$$\widehat{nx_t} = \frac{c_H^\star}{nx}\widehat{c_{H,t}^\star} - \frac{p_F c_F}{nx}\left(\widehat{p_{F,t}} + \widehat{c_{F,t}}\right)$$

- Current Account

$$\widehat{ca_t} = \frac{c_H^\star}{ca}\widehat{c_{H,t}^\star} - \frac{p_F c_F}{y}\widehat{p_{F,t}} - \frac{p_F c_F}{y}\widehat{c_{F,t}} - \frac{r}{ca}\frac{pd}{e}\left(\widehat{r_{t-1}} + \widehat{p_t} + \widehat{d_t} - \widehat{e_t}\right)$$

- Change in NFA

$$\begin{aligned}
\Delta nfa\widehat{\Delta nfa_t} =& -\mu_g\frac{dp}{e}\left[\widehat{g_t} + \mathrm{E}_t[\widehat{d_{t+1}}] + \widehat{p_t} - \widehat{e_t}\right] \\
& \frac{dp}{e}\left[\widehat{d_t} + \widehat{p_{t-1}} - \widehat{e_{t-1}}\right] \\
\Leftrightarrow \qquad \widehat{\Delta nfa_t} =& \frac{1}{\mu_g - 1}\left[\mu_g\widehat{g_t} + \mu_g\mathrm{E}_t[\widehat{d_{t+1}}] - \widehat{d_t} + \mu_g\widehat{p_t} - \widehat{p_{t-1}} - \mu_g\widehat{e_t} + \widehat{e_{t-1}}\right]
\end{aligned}$$

- Valuation Effects

  Valuation effects are zero in steady state. Therefore, we cannot determine its log–deviation from steady state. Absolute deviation from steady state is given by

$$\Delta val_t = \Delta\left(\Delta nfa_t\right) - \Delta ca_t$$

- Transitory Technology Process

$$\widehat{z_t} = \rho_z\widehat{z_{t-1}} + \epsilon_t^z$$

- Permanent Technology Process

$$\widehat{g_t} = \rho_g\widehat{g_{t-1}} + \epsilon_t^g$$

- Foreign Consumption Process

$$\widehat{c_t^\star} = \rho_c \widehat{c_{t-1}^\star} + \epsilon_t^c$$

These conditions constitute a linear system of (expectational) difference equations of the form

$$\widetilde{\mathbf{A}}\, \mathrm{E}_t\left[\widehat{\mathbf{x}}_{t+1}\right] = \widetilde{\mathbf{B}}\, \widehat{\mathbf{x}}_t,$$

where

$$\mathrm{E}_t\left[\widehat{\mathbf{x}}_{t+1}\right] = \begin{pmatrix} \mathrm{E}_t\left[\widehat{\mathbf{x}}_{e,t+1}\right] \\ \mathrm{E}_t\left[\widehat{\mathbf{x}}_{x,t+1}\right] \\ \mathrm{E}_t\left[\widehat{\mathbf{x}}_{c,t+1}\right] \end{pmatrix} = \begin{pmatrix} \mathrm{E}_t\left[\widehat{\mathbf{x}}_{s,t+1}\right] \\ \mathrm{E}_t\left[\widehat{\mathbf{x}}_{c,t+1}\right] \end{pmatrix},$$

and $\widehat{\mathbf{x}}_{s,t+1} \equiv \left[\widehat{\mathbf{x}}_{e,t+1} \quad \widehat{\mathbf{x}}_{x,t+1}\right]'$ denotes the vector of state variables in log–deviations from steady state.

Next, we use the methodology suggested by Klein (2000) to solve the log–linear approximation of the model. This approach allows to express the model in state space form:

- *Measurement Equation*

$$\widehat{\mathbf{x}}_{c,t} = \mathbf{Z}\, \widehat{\mathbf{x}}_{s,t}$$

- *Transition Equation*

$$\widehat{\mathbf{x}}_{s,t} = \mathbf{T}\, \widehat{\mathbf{x}}_{s,t-1} + \mathbf{R}\boldsymbol{\epsilon}_t, \qquad \boldsymbol{\epsilon}_t \sim \mathcal{N}(\mathbf{0}, \boldsymbol{\Sigma})$$

with

$$\mathbf{R} = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

$$\boldsymbol{\epsilon}_t = \begin{pmatrix} \epsilon_t^z \\ \epsilon_t^g \\ \epsilon_t^c \end{pmatrix}$$

$$\boldsymbol{\Sigma} = \begin{pmatrix} \sigma_z^2 & 0 & 0 \\ 0 & \sigma_g^2 & 0 \\ 0 & 0 & \sigma_c^2 \end{pmatrix}.$$

B.3 Estimation Results

B.3.1 Data for Estimation

Our estimation exercise relies on quarterly data of real per capita output and consumption as well as gross real interest rates and real exchange rates. The data section in Chapter 3 describes how we construct these real time series.

Figures B.1 to B.12 plot the series of our four variables in logs and the associated cubic trends for each country under investigation. The second row in each graph shows the cycle of the corresponding variable calculated by the log–deviation from the cubic trend.

Figure B.1: Output and Consumption – Mexico

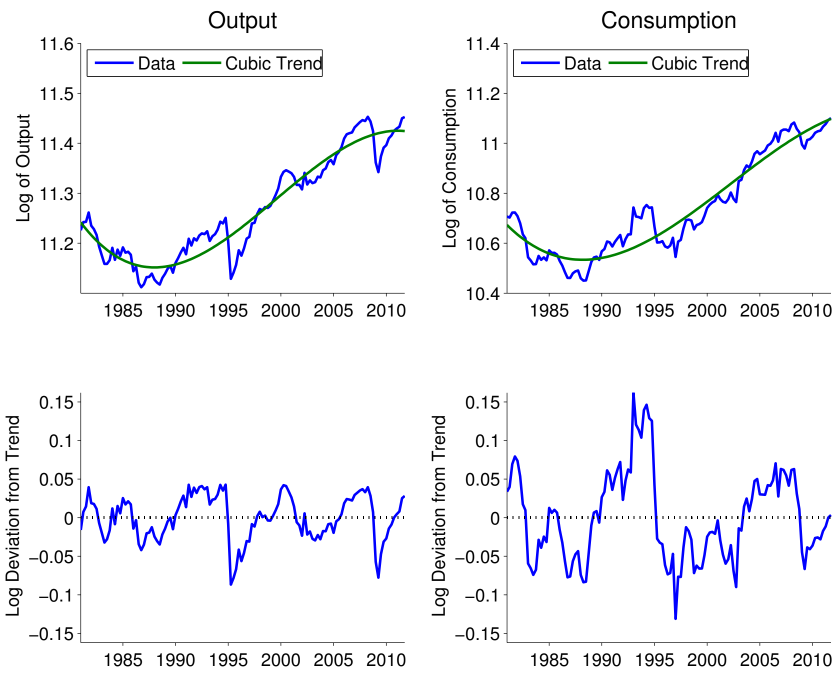


Figure B.2: Interest and Exchange Rates – Mexico

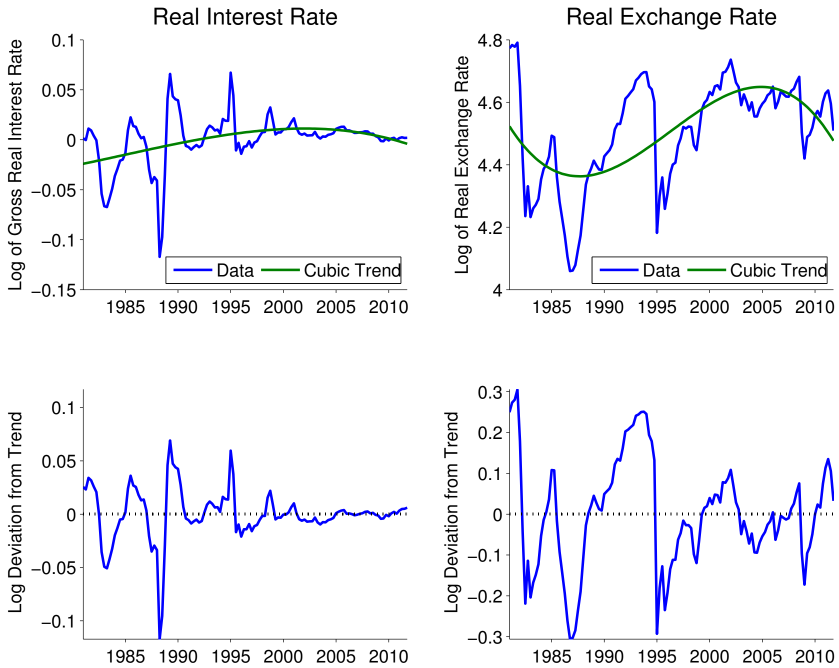


Figure B.3: Output and Consumption – South Africa

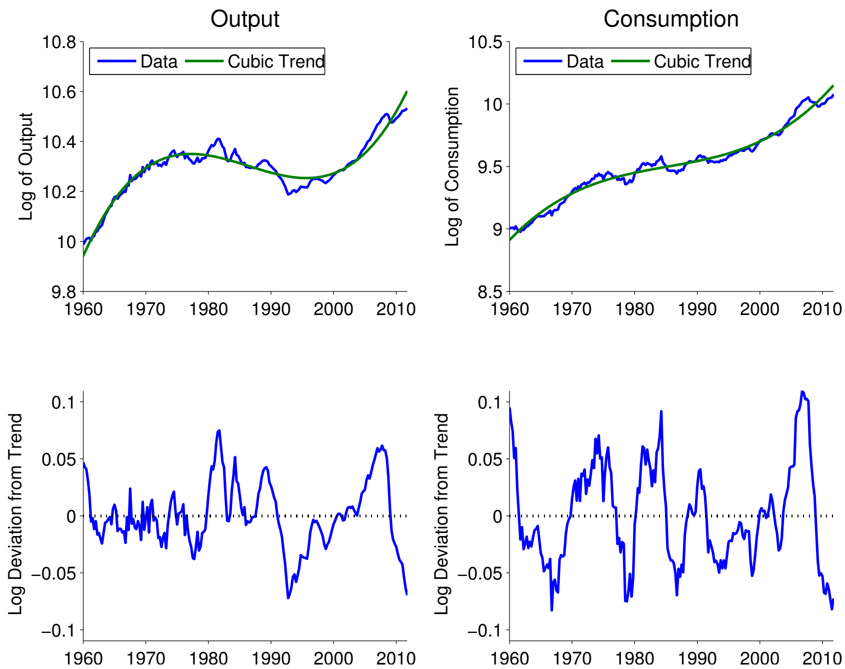


Figure B.4: Interest and Exchange Rates – South Africa

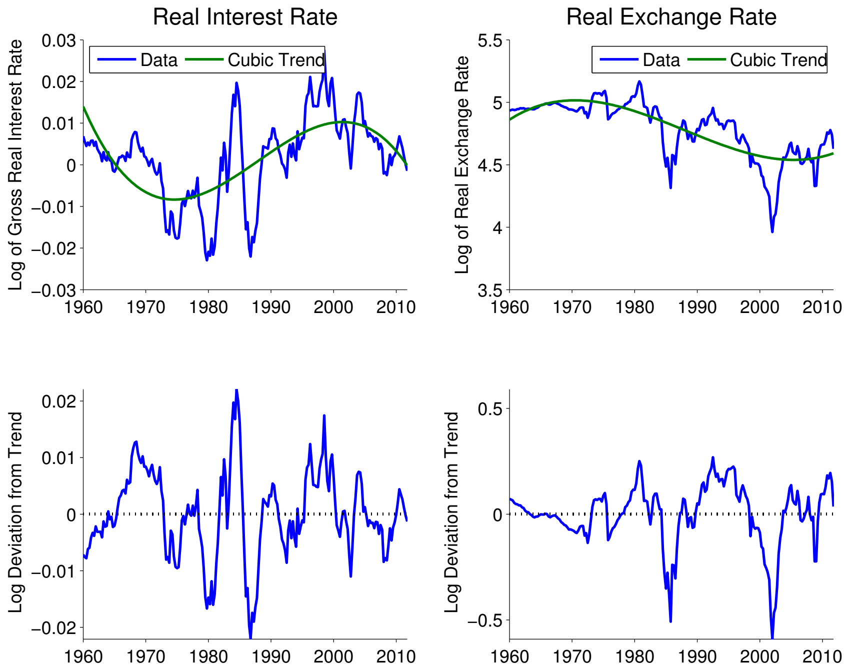


Figure B.5: Output and Consumption – Turkey

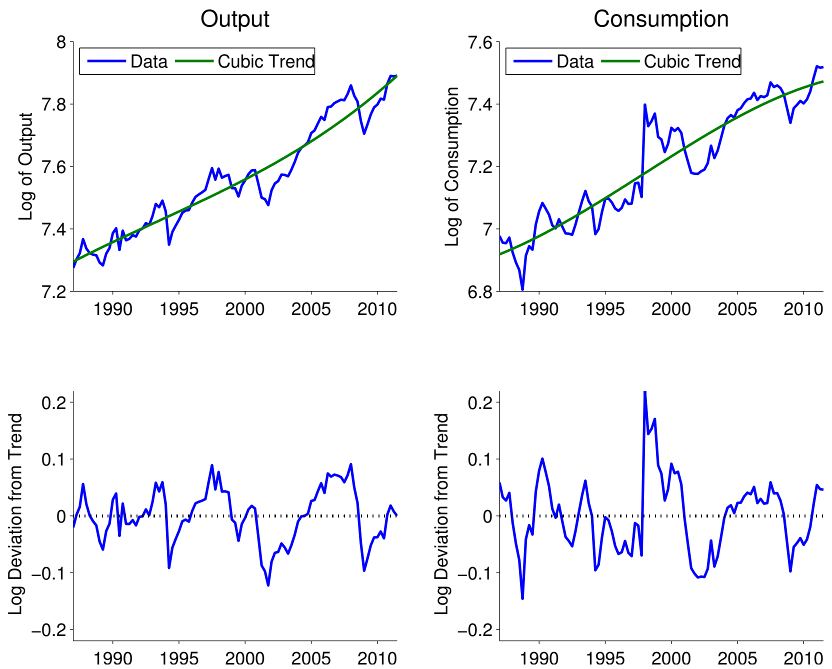


Figure B.6: Interest and Exchange Rates – Turkey

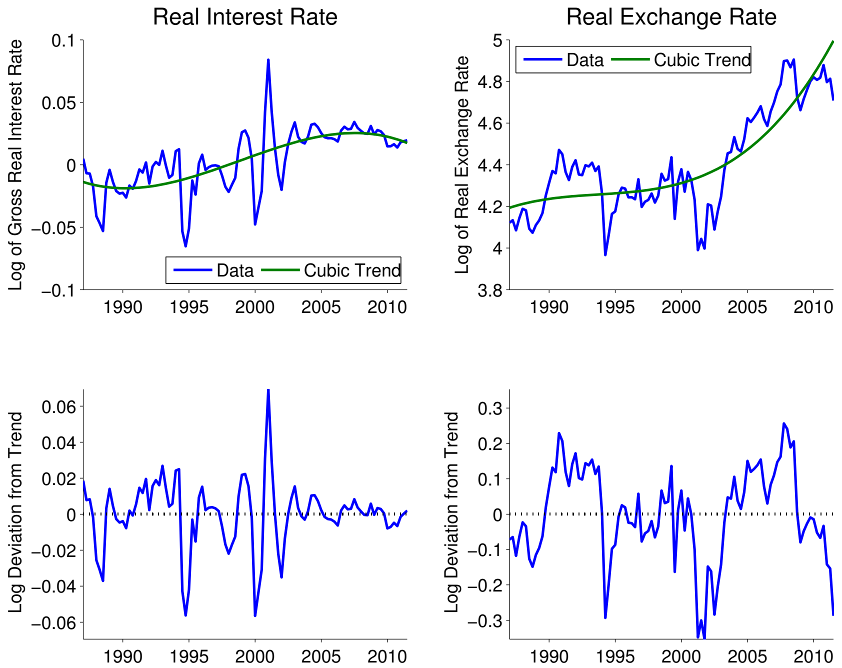


Figure B.7: Output and Consumption – Canada

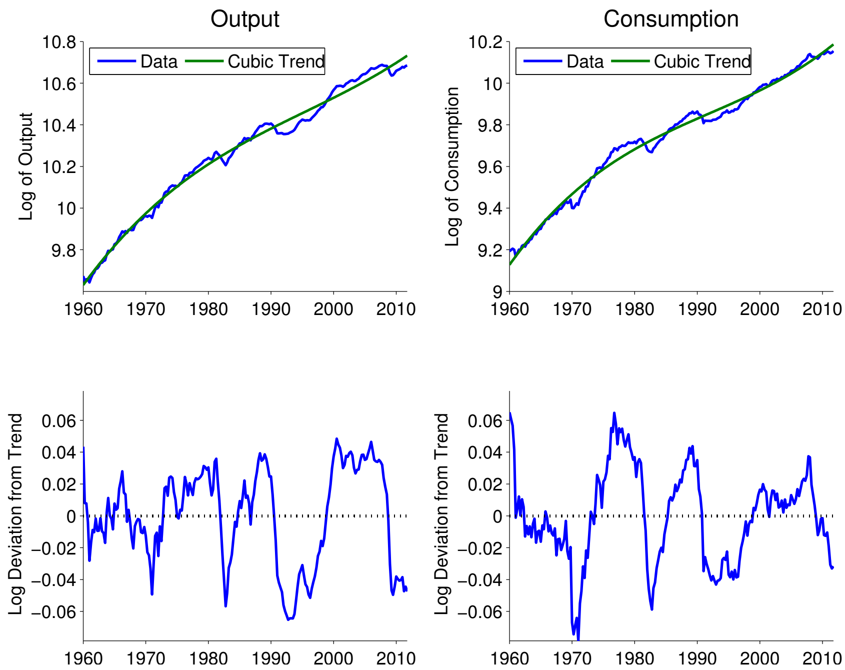


Figure B.8: Interest and Exchange Rates – Canada

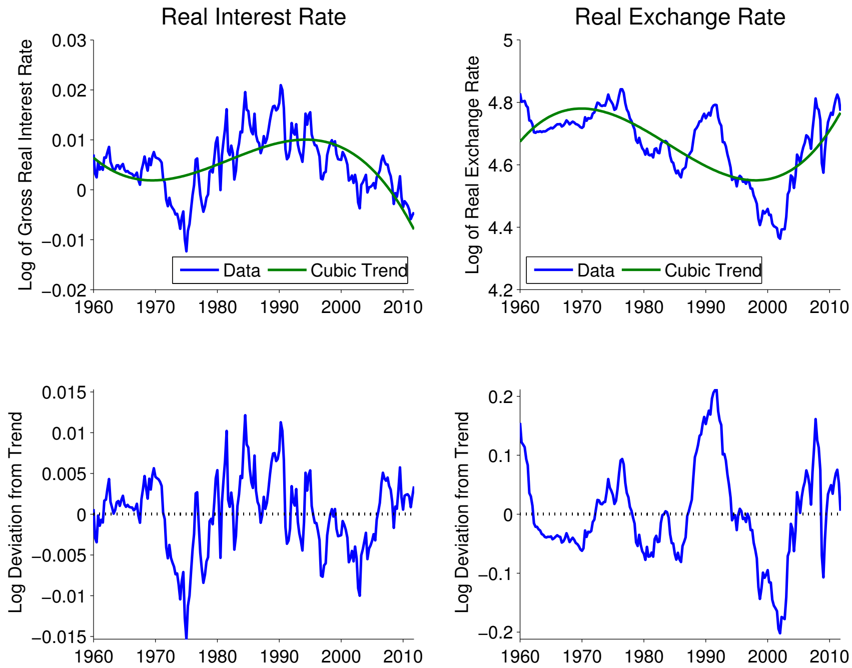


Figure B.9: Output and Consumption – Sweden

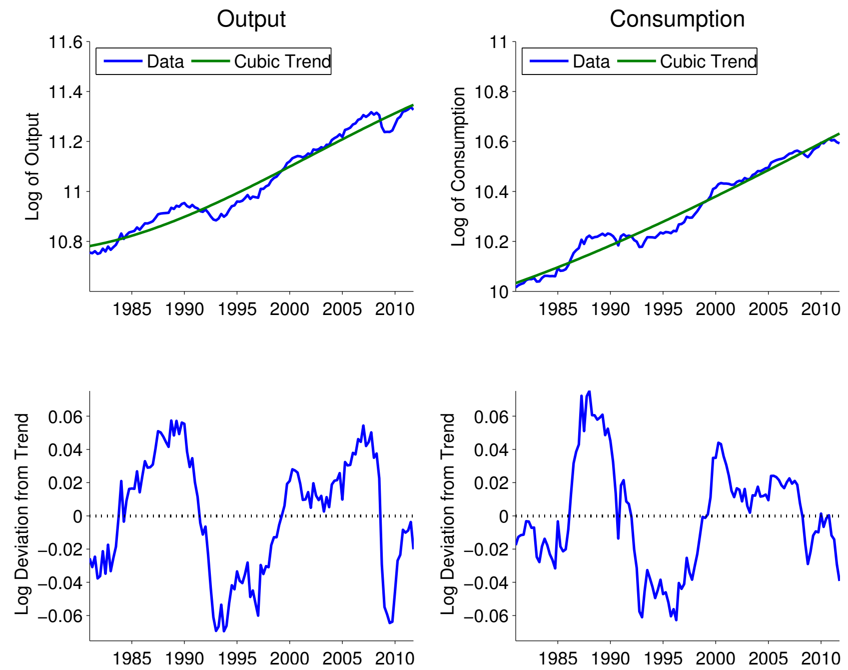


Figure B.10: Interest and Exchange Rates – Sweden

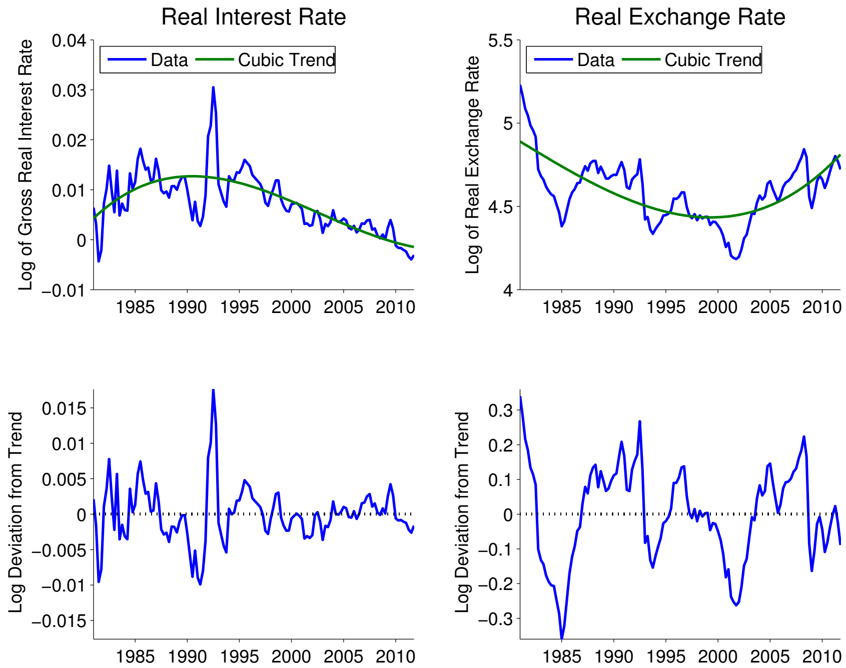


Figure B.11: Output and Consumption – Switzerland

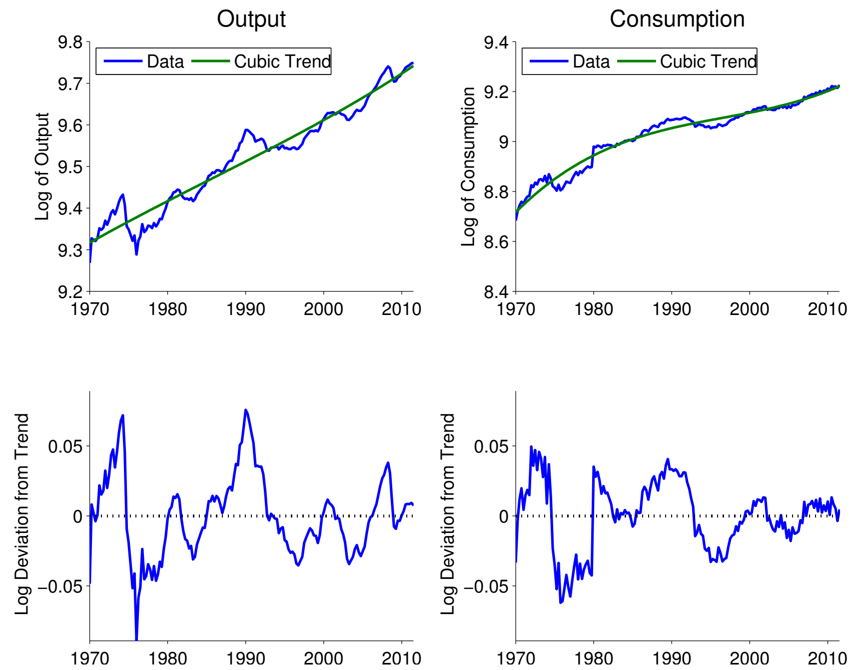
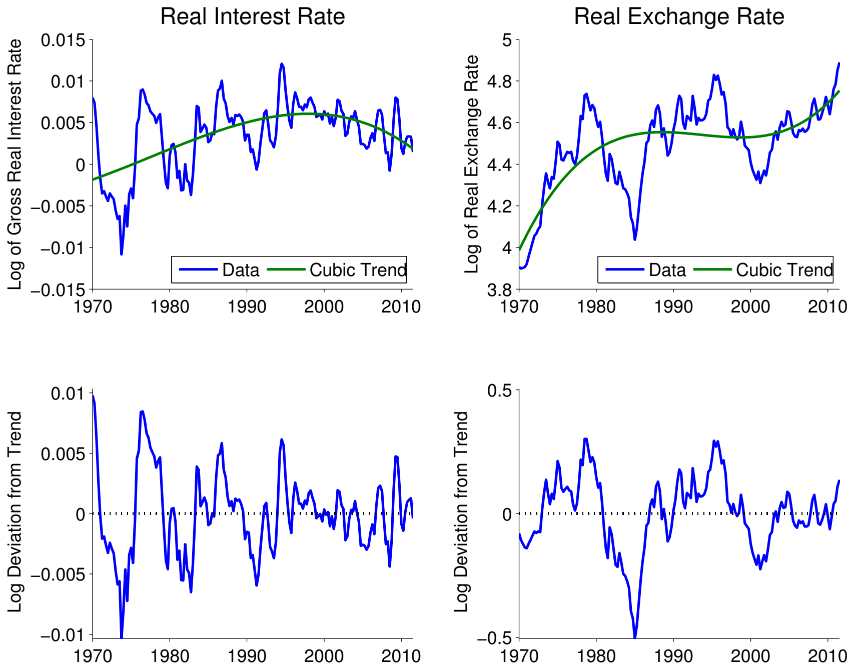


Figure B.12: Interest and Exchange Rates – Switzerland



B.3.2 Parameter Distributions

Table B.1 complements Table 3.5 in the main text and presents a detailed summary of the posterior distributions of our estimated parameters including those determining the off–model dynamics.

Table B.1: Prior & Posterior Distributions – Emerging Market Economies

	Post. Median	Post. 90%	χ^2 Test	Post. Median	Post. 90%	χ^2 Test
	Mexico					
	Benchmark			**Liability Dollarisation**		
ψ	4.342	[3.315,4.885]	0.27	0.216	[0.088,0.488]	0.96
ρ_z	0.622	[0.487,0.744]	0.58	0.708	[0.574,0.828]	0.50
ρ_g	0.751	[0.637,0.845]	0.58	0.790	[0.632,0.890]	0.26
ρ_c	0.689	[0.458,0.875]	0.37	0.547	[0.365,0.726]	0.21
ρ_{ϵ_y}	0.251	[-0.007,0.510]	0.59	0.221	[-0.037,0.504]	0.98
ρ_{ϵ_c}	0.876	[0.782,0.936]	0.74	0.743	[0.204,0.897]	0.65
ρ_{ϵ_r}	0.708	[0.625,0.787]	0.27	0.747	[0.676,0.820]	0.57
ρ_{ϵ_e}	0.836	[0.760,0.897]	0.58	0.837	[0.772,0.897]	0.62
σ^2_z	0.034	[0.028,0.043]	0.91	0.036	[0.029,0.044]	0.79
σ^2_g	0.040	[0.031,0.052]	0.26	0.029	[0.021,0.039]	0.83
σ^2_c	0.128	[0.082,0.201]	0.89	0.189	[0.106,0.370]	0.45
$\sigma^2_{\epsilon_y}$	0.006	[0.004,0.008]	0.26	0.006	[0.005,0.009]	0.32
$\sigma^2_{\epsilon_c}$	0.024	[0.019,0.031]	0.74	0.027	[0.019,0.038]	0.15
$\sigma^2_{\epsilon_r}$	0.021	[0.018,0.025]	0.60	0.023	[0.020,0.027]	0.95
$\sigma^2_{\epsilon_e}$	0.320	[0.260,0.387]	0.81	0.330	[0.269,0.399]	0.12
	Canada					
	Benchmark					
ψ	2.335	[1.646,3.573]	0.14			
ρ_z	0.901	[0.852,0.948]	0.38			
ρ_g	0.757	[0.676,0.832]	0.91			
ρ_c	0.920	[0.860,0.958]	0.53			
ρ_{ϵ_y}	0.704	[0.474,0.875]	0.47			
ρ_{ϵ_c}	0.827	[0.701,0.894]	0.75			
ρ_{ϵ_r}	0.465	[0.238,0.677]	0.76			
ρ_{ϵ_e}	0.913	[0.863,0.953]	0.46			
σ^2_z	0.013	[0.011,0.015]	0.70			
σ^2_g	0.009	[0.008,0.011]	0.56			
σ^2_c	0.047	[0.038,0.058]	0.88			
$\sigma^2_{\epsilon_y}$	0.004	[0.003,0.005]	0.15			
$\sigma^2_{\epsilon_c}$	0.005	[0.004,0.006]	0.76			
$\sigma^2_{\epsilon_r}$	0.000	[0.000,0.000]	0.48			
$\sigma^2_{\epsilon_e}$	0.040	[0.033,0.047]	0.74			

	Post. Median	Post. 90%	χ^2 Test	Post. Median	Post. 90%	χ^2 Test
	South Africa					
	Benchmark			**Liability Dollarisation**		
ψ	1.664	[1.115,2.668]	0.31	0.275	[0.158,0.420]	0.93
ρ_z	0.918	[0.874,0.958]	0.50	0.782	[0.679,0.863]	0.92
ρ_g	0.827	[0.767,0.886]	0.86	0.797	[0.690,0.869]	0.95
ρ_c	0.626	[0.442,0.815]	0.43	0.654	[0.466,0.798]	0.59
ρ_{ϵ_y}	0.233	[0.010,0.489]	0.94	0.282	[0.041,0.551]	0.35
ρ_{ϵ_c}	0.925	[0.890,0.958]	0.82	0.908	[0.859,0.949]	0.36
ρ_{ϵ_r}	0.434	[0.186,0.686]	0.68	0.802	[0.548,0.888]	0.93
ρ_{ϵ_e}	0.913	[0.876,0.948]	0.80	0.904	[0.865,0.943]	0.15
σ^2_z	0.015	[0.014,0.018]	0.85	0.020	[0.017,0.023]	0.91
σ^2_g	0.012	[0.010,0.014]	0.22	0.016	[0.012,0.021]	0.86
σ^2_c	0.082	[0.059,0.110]	0.34	0.086	[0.058,0.137]	0.56
$\sigma^2_{\epsilon_y}$	0.004	[0.003,0.005]	0.33	0.004	[0.003,0.005]	0.55
$\sigma^2_{\epsilon_c}$	0.017	[0.014,0.021]	0.49	0.014	[0.011,0.018]	0.77
$\sigma^2_{\epsilon_r}$	0.000	[0.000,0.001]	0.17	0.001	[0.000,0.001]	0.66
$\sigma^2_{\epsilon_e}$	0.284	[0.251,0.320]	0.06	0.272	[0.238,0.307]	0.19
	Sweden					
	Benchmark					
ψ	2.490	[1.486,4.103]	0.89			
ρ_z	0.885	[0.829,0.939]	0.95			
ρ_g	0.597	[0.488,0.706]	0.15			
ρ_c	0.738	[0.523,0.878]	0.53			
ρ_{ϵ_y}	0.411	[0.139,0.679]	0.37			
ρ_{ϵ_c}	0.773	[0.651,0.865]	0.20			
ρ_{ϵ_r}	0.275	[0.024,0.510]	0.71			
ρ_{ϵ_e}	0.878	[0.829,0.925]	0.95			
σ^2_z	0.022	[0.018,0.025]	0.46			
σ^2_g	0.018	[0.015,0.022]	0.80			
σ^2_c	0.074	[0.055,0.102]	0.55			
$\sigma^2_{\epsilon_y}$	0.007	[0.005,0.009]	0.09			
$\sigma^2_{\epsilon_c}$	0.011	[0.009,0.014]	0.83			
$\sigma^2_{\epsilon_r}$	0.000	[0.000,0.000]	0.62			
$\sigma^2_{\epsilon_e}$	0.285	[0.244,0.332]	0.85			

	Post. Median	Post. 90%	χ^2 Test	Post. Median	Post. 90%	χ^2 Test
	Turkey					
	Benchmark			**Liability Dollarisation**		
ψ	4.067	[2.743,4.830]	0.50	0.455	[0.126,1.182]	0.86
ρ_z	0.691	[0.552,0.803]	0.25	0.648	[0.512,0.763]	0.24
ρ_g	0.629	[0.508,0.741]	0.46	0.705	[0.561,0.811]	0.10
ρ_c	0.646	[0.428,0.822]	0.49	0.507	[0.338,0.655]	0.48
ρ_{ϵ_y}	0.345	[0.030,0.730]	0.48	0.230	[-0.050,0.568]	0.91
ρ_{ϵ_c}	0.620	[0.447,0.745]	0.31	0.371	[0.029,0.653]	0.37
ρ_{ϵ_r}	0.503	[0.364,0.626]	0.23	0.512	[0.384,0.626]	0.76
ρ_{ϵ_e}	0.728	[0.521,0.828]	0.08	0.778	[0.685,0.861]	0.63
σ^2_z	0.062	[0.049,0.078]	0.87	0.059	[0.045,0.075]	0.49
σ^2_g	0.080	[0.060,0.107]	0.14	0.074	[0.053,0.101]	0.66
σ^2_c	0.201	[0.114,0.384]	0.12	0.192	[0.103,0.428]	0.20
$\sigma^2_{\epsilon_y}$	0.023	[0.015,0.037]	0.83	0.022	[0.015,0.036]	0.36
$\sigma^2_{\epsilon_c}$	0.092	[0.069,0.119]	0.75	0.059	[0.038,0.088]	0.21
$\sigma^2_{\epsilon_r}$	0.015	[0.011,0.019]	0.63	0.020	[0.015,0.024]	0.89
$\sigma^2_{\epsilon_e}$	0.560	[0.411,0.689]	0.33	0.671	[0.549,0.816]	0.68
	Switzerland					
	Benchmark					
ψ	0.165	[0.141,0.193]	0.54			
ρ_z	0.880	[0.826,0.931]	0.55			
ρ_g	0.596	[0.486,0.699]	0.52			
ρ_c	0.697	[0.515,0.835]	0.92			
ρ_{ϵ_y}	0.354	[0.118,0.610]	0.43			
ρ_{ϵ_c}	0.830	[0.761,0.887]	0.57			
ρ_{ϵ_r}	0.303	[0.085,0.522]	0.87			
ρ_{ϵ_e}	0.931	[0.896,0.964]	0.58			
σ^2_z	0.014	[0.013,0.016]	0.48			
σ^2_g	0.012	[0.010,0.014]	0.89			
σ^2_c	0.093	[0.067,0.129]	0.25			
$\sigma^2_{\epsilon_y}$	0.004	[0.003,0.005]	0.70			
$\sigma^2_{\epsilon_c}$	0.008	[0.006,0.010]	0.92			
$\sigma^2_{\epsilon_r}$	0.000	[0.000,0.000]	0.37			
$\sigma^2_{\epsilon_e}$	0.239	[0.209,0.276]	0.33			

Notes: Results are based on 150,000 draws from the posterior distribution, of which for EMEs 100,000, and for developed economies the first 125,000 draws were burned. To avoid autocorrelation issues, we only keep every 10^{th} draw for developed economies, and every 25^{th} for EMEs. The χ^2 figure denotes the p–value of Geweke's χ^2–test for convergence (4% taper). Variances are reported in percentages.

B.3.3 Random Walk Component of the Solow Residual

Aguiar and Gopinath (2007) assess the relative importance of trend shocks by calculating the random walk component (RWC) of the Solow residual. Recall that our production function is given by

$$Y_t = z_t K_t^{\alpha} (\Gamma_t l_t)^{1-\alpha}.$$

Hence, we can define total factor productivity (TFP) as

$$TFP_t = z_t \Gamma_t^{1-\alpha},$$

such that our production function reads

$$Y_t = TFP_t K_t^{\alpha} l_t^{1-\alpha}.$$

Log output in first differences is then

$$\Delta \log(Y_t) = \Delta \log(TFP_t) + \alpha \Delta \log(K_t) + (1-\alpha)\Delta \log(l_t),$$

where

$$\begin{aligned} & \Delta \log(TFP_t) = \Delta \log(z_t) + (1-\alpha)\Delta \log(\Gamma_t) \\ \Leftrightarrow \quad & \Delta \log(TFP_t) = \Delta \log(z_t) + (1-\alpha)\left(\log(g_t) + \log(\Gamma_{t-1}) - \log(\Gamma_{t-1})\right) \\ \Leftrightarrow \quad & \Delta \log(TFP_t) = \Delta \log(z_t) + (1-\alpha)\log(g_t) \end{aligned}$$

is the famous Solow residual.

The variance of the Solow residual is given by the sum of the variance of $\Delta \log(z_t)$ and the variance of $(1-\alpha)\log(g_t)$. Let us first compute the variance of $\log(g_t)$:

$$\begin{aligned} & Var(\log(g_t)) = Var((1-\rho_g)\mu_g + \rho_g \log(g_{t-1}) + \epsilon_t^g) \\ \Leftrightarrow \quad & Var(\log(g_t)) = \rho_g^2 Var(\log(g_{t-1})) + \sigma_g^2 \end{aligned}$$

$$\Leftrightarrow \qquad Var(\log(g_t)) = \frac{\sigma_g^2}{(1-\rho_g^2)},$$

where we use the fact that $\log(g_t)$ follows a stationary AR(1) process, such that $Var(\log(g_t)) = Var(\log(g_{t-1}))$. Next, we calculate the variance of $\Delta\log(z_t)$:

$$\begin{aligned}
& Var(\Delta\log(z_t)) = Var(\log(z_t) - \log(z_{t-1})) \\
\Leftrightarrow \qquad & Var(\Delta\log(z_t)) = Var(\rho_z \log(z_{t-1}) + \epsilon_t^z - \log(z_{t-1})) \\
\Leftrightarrow \qquad & Var(\Delta\log(z_t)) = Var(-(1-\rho_z)\log(z_{t-1}) + \epsilon_t^z) \\
\Leftrightarrow \qquad & Var(\Delta\log(z_t)) = (1-\rho_z)^2 Var(\log(z_{t-1})) + \sigma_z^2 \\
\Leftrightarrow \qquad & Var(\Delta\log(z_t)) = (1-\rho_z)^2 \frac{\sigma_z^2}{(1-\rho_z^2)} + \sigma_z^2 \\
\Leftrightarrow \qquad & Var(\Delta\log(z_t)) = (1-\rho_z)^2 \frac{\sigma_z^2}{(1+\rho_z)(1-\rho_z)} + \sigma_z^2 \\
\Leftrightarrow \qquad & Var(\Delta\log(z_t)) = (1-\rho_z) \frac{\sigma_z^2}{(1+\rho_z)} + \sigma_z^2 \\
\Leftrightarrow \qquad & Var(\Delta\log(z_t)) = \left(\frac{1-\rho_z}{1+\rho_z} + 1\right)\sigma_z^2 \\
\Leftrightarrow \qquad & Var(\Delta\log(z_t)) = \frac{2}{1+\rho_z}\sigma_z^2,
\end{aligned}$$

where, again, we use the fact that $\log(z_t)$ follows a stationary AR(1) process, such that $Var(\log(z_t)) = Var(\log(z_{t-1}))$. Accordingly, the variance of the Solow residual is given by

$$\begin{aligned}
& Var(\Delta\log(TFP_t)) = Var(\Delta\log(z_t)) + (1-\alpha)^2 Var(\log(g_t)) \\
\Leftrightarrow \qquad & Var(\Delta\log(TFP_t)) = \frac{2\sigma_z^2}{1+\rho_z} + \frac{(1-\alpha)^2\sigma_g^2}{(1-\rho_g^2)}.
\end{aligned}$$

The random walk component of the Solow residual is then the portion of the variance of $\Delta\log(TFP_t)$ that can be attributed to the non–stationary productivity component:

$$RWC = \frac{\frac{(1-\alpha)^2\sigma_g^2}{(1-\rho_g^2)}}{\frac{2\sigma_z^2}{1+\rho_z} + \frac{(1-\alpha)^2\sigma_g^2}{(1-\rho_g^2)}}.$$

Note that this equation is the counterpart of equation (14) in the paper by Aguiar and Gopinath (2007).

Table B.2 summarises the RWC of the Solow residual as well as the ratio of standard deviations $\frac{\sigma_g}{\sigma_z}$ computed at the median of the posterior distribution. For Mexico and Canada we also report the GMM estimates obtained by Aguiar and Gopinath (2007).

Table B.2: Random Walk Component and Volatility Ratio

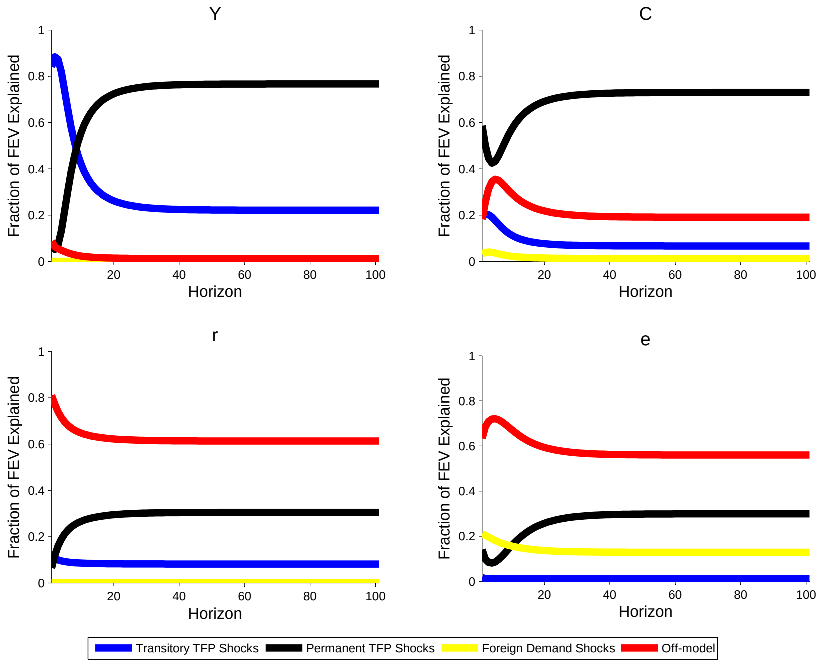
	Benchmark	Liability Dollarisation	AG (2007)
	Random Walk Component		
Emerging Markets			
MEX	0.88	0.88	0.88
ZAF	0.92	0.89	
TUR	0.79	0.85	
Developed Economies			
CAN	0.84		0.40
SWE	0.69		
CHE	0.70		
	Ratio of Volatilities $\frac{\sigma_g}{\sigma_z}$		
Emerging Markets			
MEX	1.09	0.90	4.02
ZAF	0.89	0.89	
TUR	1.14	1.12	
Developed Economies			
CAN	0.83		0.75
SWE	0.90		
CHE	0.93		

Our calculations suggest that the RWC does not differ substantially across models. It is somewhat higher in the model with liability dollarisation than in the benchmark model for Turkey, whereas it is the reverse for South Africa. Moreover, we find that the RWC is smaller in developed economies than in EMEs. This finding corroborates the result of Aguiar and Gopinath (2007) and explains why our analysis finds support for their hypothesis that *"the cycle is the trend"* in emerging markets.

B.4 Forecast Error Variance Decomposition

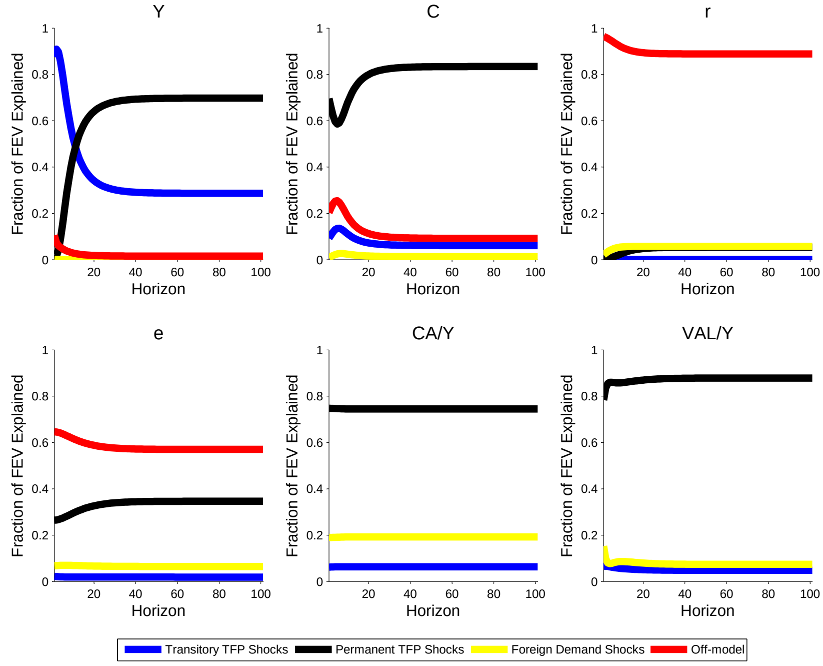
This section presents forecast error variance decompositions for the three EMEs and developed economies in our analysis. In each specification, we focus on the respective model parametrised at the median of the posterior distributions. Figures B.13 to B.18 display the variance decompositions of the benchmark economy as well as the model with liability dollarisation for Mexico, South Africa, and Turkey. Figures B.19 to B.21, show the variance decompositions of the benchmark model for Canada, Sweden, and Switzerland.

Figure B.13: Forecast Error Variance Decomposition – Mexico Benchmark



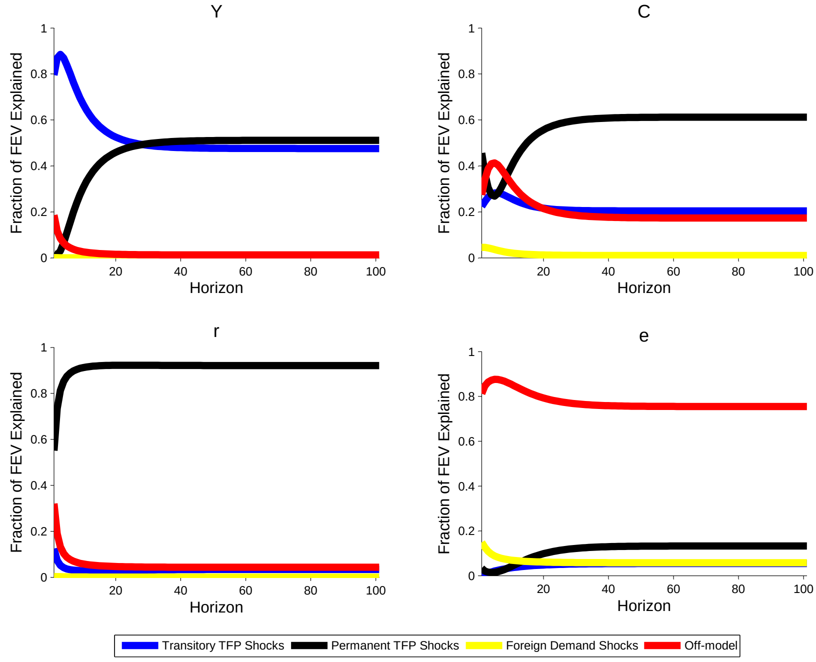
Notes: Forecast error variance decomposition based on median outcomes of the posterior distribution for the benchmark model estimated for Mexico.

Figure B.14: Forecast Error Variance Decomposition – Mexico Liability Dollarisation



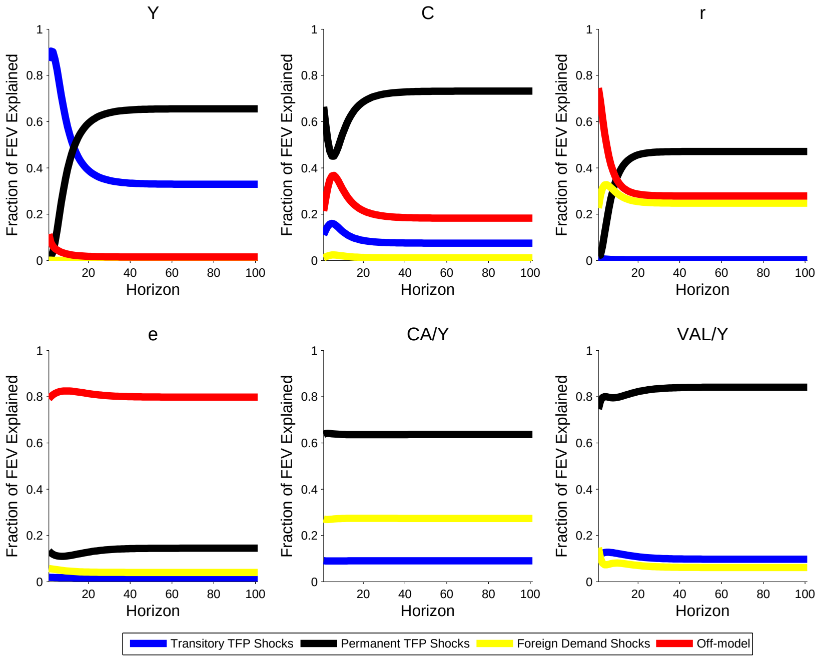
Notes: Forecast error variance decomposition based on median outcomes of the posterior distribution for the liability dollarisation model estimated for Mexico.

Figure B.15: Forecast Error Variance Decomposition – South Africa Benchmark



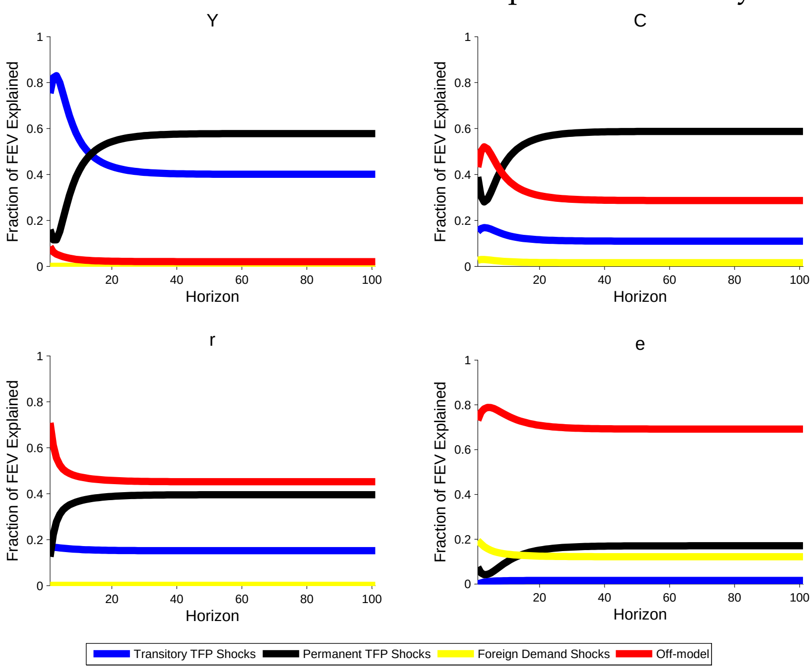
Notes: Forecast error variance decomposition based on median outcomes of the posterior distribution for the benchmark model estimated for South Africa.

Figure B.16: Forecast Error Variance Decomposition – South Africa Liability Dollarisation



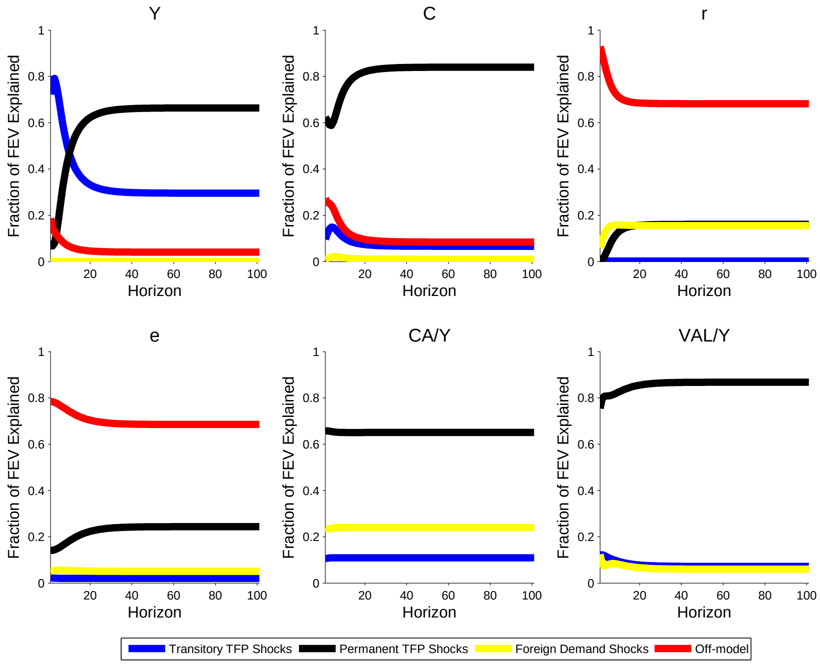
Notes: Forecast error variance decomposition based on median outcomes of the posterior distribution for the liability dollarisation model estimated for South Africa.

Figure B.17: Forecast Error Variance Decomposition – Turkey Benchmark



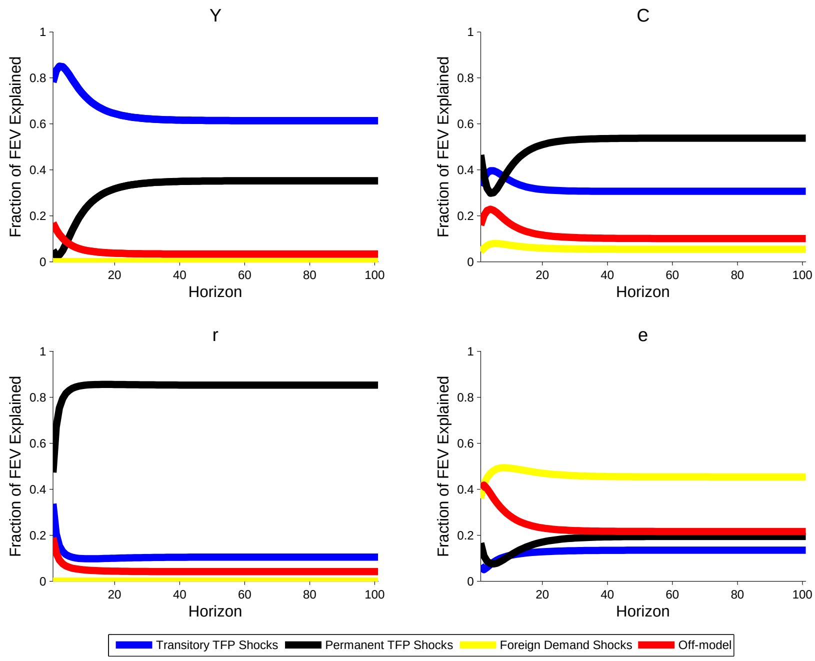
Notes: Forecast error variance decomposition based on median outcomes of the posterior distribution for the benchmark model estimated for Turkey.

Figure B.18: Forecast Error Variance Decomposition – Turkey Liability Dollarisation



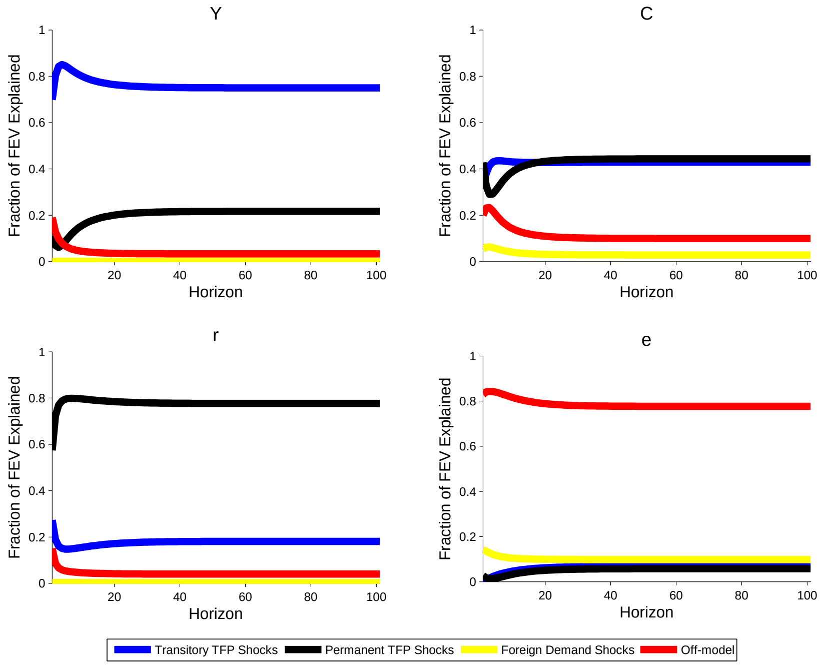
Notes: Forecast error variance decomposition based on median outcomes of the posterior distribution for the liability dollarisation model estimated for Turkey.

Figure B.19: Forecast Error Variance Decomposition – Canada



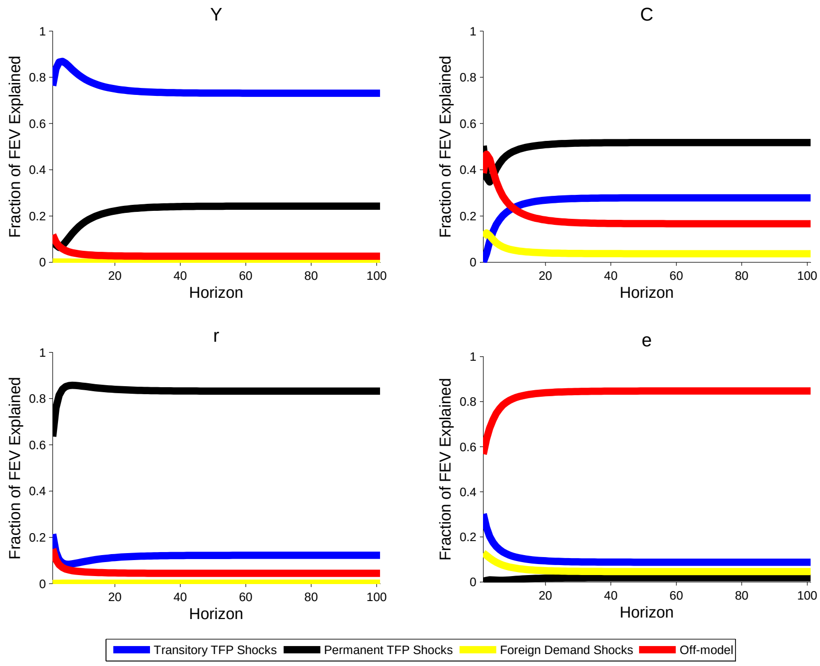
Notes: Forecast error variance decomposition based on median outcomes of the posterior distribution estimated for Canada.

Figure B.20: Forecast Error Variance Decomposition – Sweden



Notes: Forecast error variance decomposition based on median outcomes of the posterior distribution estimated for Sweden.

Figure B.21: Forecast Error Variance Decomposition – Switzerland



Notes: Forecast error variance decomposition based on median outcomes of the posterior distribution estimated for Switzerland.

B.5 Impulse Responses

This section contrasts the impulse responses of the model with liability dollarisation with those implied by the benchmark model. For this purpose, we choose the same parametrisation for both models. In particular, we calibrate the debt–elasticity of the interest rate ψ and the parameters governing the exogenous processes at the median of the posterior distributions estimated for Mexico in the liability dollarisation setup. That is, we set $\psi = 0.216$, $\rho_z = 0.708$, $\rho_z = 0.790$, and $\rho_z = 0.547$.

Figures B.22, B.23, and B.24 show the impulse responses after a one percent shock to the permanent productivity process, transitory productivity process, and foreign consumption, respectively.

Figure B.22: Impulse Responses to a Permanent Shock

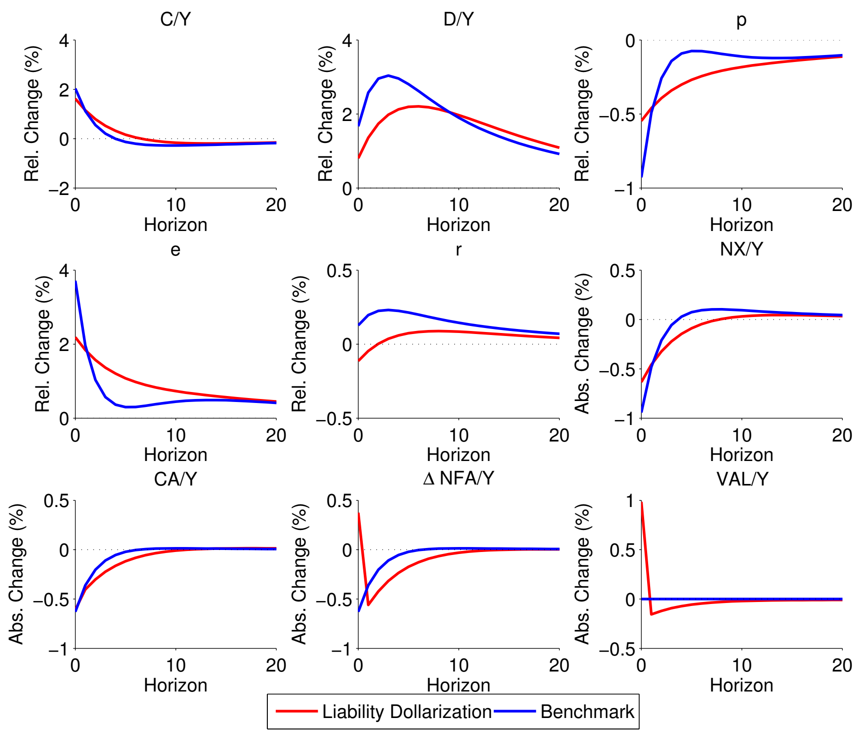


Figure B.23: Impulse Responses to a Transitory Shock

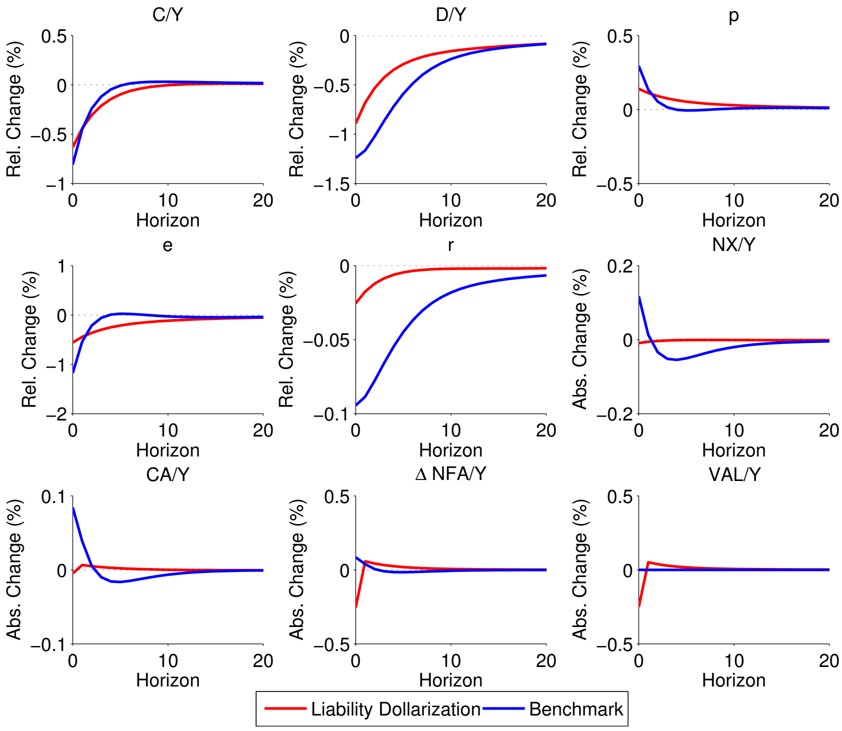
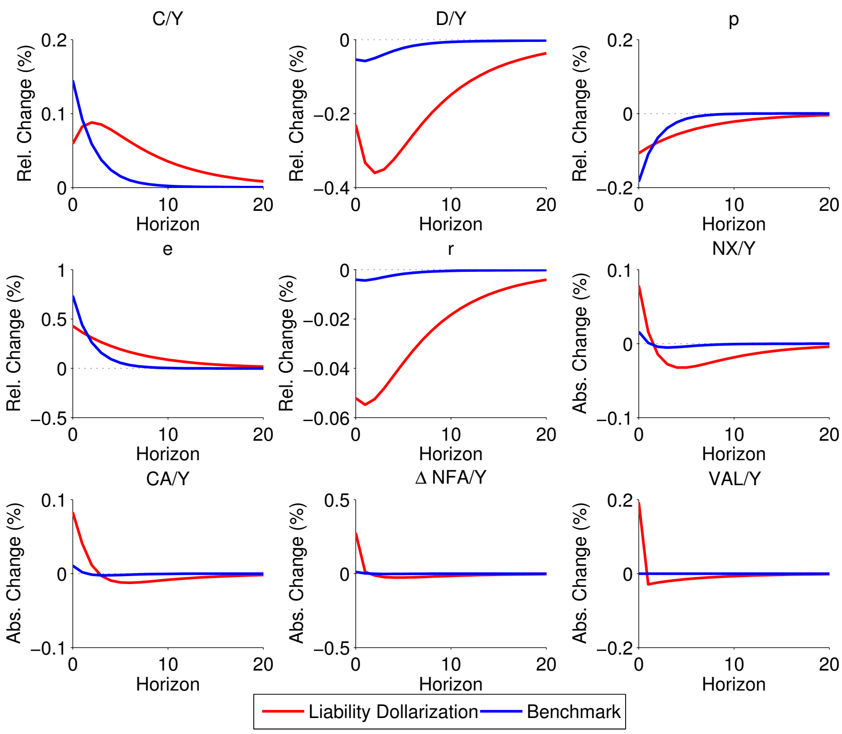


Figure B.24: Impulse Responses to a Foreign Demand Shock



B.6 Business Cycle Moments

Table B.3 shows model implied business cycle moments and their empirical counterparts. The table complements the table presented in Section 3.6.3 in the main text. Here, we simulate the benchmark and the liability dollarisation model, each evaluated at the median of the respective posterior distributions, for our three EMEs. Again, we generate time series with 100 observations and subsequently compute sample moments based on the detrended series of our variables. Table B.3 reports the median of our calculated moments across all 5,000 simulations.

Table B.3: Business Cycle Moments in Emerging Market Economies

	Data	Liability Dollarisation	Benchmark	Data	Liability Dollarisation	Benchmark	Data	Liability Dollarisation	Benchmark
		Mexico			**S. Africa**			**Turkey**	
$\sigma(Y)$	2.42	5.31	5.82	1.60	4.25	5.57	3.70	6.30	6.51
$\sigma(C)$	3.68	6.71	7.05	2.46	5.08	5.60	5.72	7.65	7.12
$\sigma(NX/Y)$	6.63	1.58	0.97	4.04	0.95	0.53	3.42	1.46	0.95
$\sigma(e)$	9.63	7.71	6.78	8.70	5.05	5.47	9.54	7.47	7.14
$\sigma(C)/\sigma(Y)$	1.52	1.57	1.47	1.54	1.41	1.01	1.55	1.45	1.20
$\rho(C, Y)$	0.74	0.77	0.92	0.67	0.82	0.91	0.62	0.86	0.92
$\rho(NX/Y, Y)$	−0.17	−0.10	−0.45	−0.40	−0.19	−0.32	−0.56	−0.27	−0.52
$\rho(e, NX/Y)$	−0.31	−0.62	−0.25	−0.12	−0.43	−0.06	−0.45	−0.48	−0.19
$\rho(Y_t, Y_{t-1})$	0.78	0.88	0.89	0.81	0.90	0.96	0.73	0.83	0.83
$\rho(C_t, C_{t-1})$	0.75	0.84	0.83	0.83	0.86	0.90	0.70	0.79	0.76
$\rho((NX/Y)_t, (NX/Y)_{t-1})$	0.97	0.69	0.29	0.85	0.67	0.32	0.84	0.57	0.17
$\rho(e_t, e_{t-1})$	0.79	0.83	0.76	0.80	0.85	0.84	0.62	0.81	0.74
$\rho((VAL/Y)_t, (CA/Y)_t)$	−0.58	−0.34		−0.75	−0.30		−0.05	−0.38	
$\rho((VAL/Y)_t, e_t)$	0.45	0.29		−0.31	0.28		0.19	0.30	

Notes: Standard deviations are expressed in percentages except for the model implied standard deviation of the net exports to output ratio, which is expressed in percentage points. Empirical moments are calculated using quarterly data taken from the IFS, apart from those involving valuation effects for which only annual data from Lane and Milesi-Ferretti (2007) are available. All series, except for the net exports over output ratio and valuation effects, are real per capita variables, have been logged, seasonally adjusted and filtered using the HP filter with smoothing parameter λ = 1,600. Theoretical moments are based on sample moments of model generated data. Each theoretical economy is simulated 5,000 times with a sample size of 100. Median outcomes are reported.

Appendix C

Appendix to "Current Account Dynamics in Emerging Markets: Is the Cycle really the Trend?"

C.1 Stochastic Growth Model

This section outlines the stochastic growth model developed by Aguiar and Gopinath (2007), augmented with an exogenous world interest rate shock.
The theoretical economy is represented by:

- Production Function

$$Y_t = z_t K_t^{\alpha} (\Gamma_t l_t)^{1-\alpha}$$

- Transitory Technology Process

$$z_t = z_{t-1}^{\rho_z} \exp(\epsilon_t^z)$$

- Permanent Technology Process

$$\Gamma_t = g_t \Gamma_{t-1} = \prod_{s=0}^{t} g_s, \quad g_t = \mu_g^{1-\rho_g} g_{t-1}^{\rho_g} \exp(\epsilon_t^g)$$

- Aggregate Resource Constraint

$$Y_t + \frac{B_{t+1}}{1+r_t} = C_t + I_t + B_t$$

- Current Account and Net Exports

$$CA_t = NX_t = Y_t - C_t - I_t = B_t - \frac{B_{t+1}}{1 + r_t}$$

- Law of Motion of Capital

$$K_{t+1} = (1 - \delta)K_t + I_t - \frac{\phi}{2}\left(\frac{K_{t+1}}{K_t} - \mu_g\right)^2 K_t$$

- Interest Rate

$$1 + r_t = R_t^\star + \psi\left(\exp\left(b_{t+1} - b\right) - 1\right)$$

- World Interest Rate Process

$$R_t^\star = (R^\star)^{1-\rho_R}(R_{t-1}^\star)^{\rho_R}\exp(\epsilon_t^R)$$

Error terms have zero means and are normally distributed: $\epsilon_t^z \sim \mathcal{N}(0, \sigma_z^2)$, $\epsilon_t^g \sim \mathcal{N}(0, \sigma_g^2)$, and $\epsilon_t^R \sim \mathcal{N}(0, \sigma_R^2)$. Preferences of the representative household are represented by a CRRA utility function:

$$u(C_t, 1 - l_t) = \frac{[C_t^\gamma (1 - l_t)^{1-\gamma}]^{1-\sigma}}{1 - \sigma}.$$

There is no population growth and the mass of population is normalised to one.

C.1.1 Detrending the Variables

Variables Y_t, C_t, I_t, K_t, CA_t, and B_t exhibit a stochastic trend. Hence, we need to detrend them in order to obtain a system of stationary variables. This can be easily achieved through division by the realisation of the permanent productivity component in the previous period:

$$x_t \equiv \frac{X_t}{\Gamma_{t-1}},$$

where x_t denotes the stationary counterpart of variable X_t.

Accordingly, the detrended versions of our equations can be derived as

- Production Function

$$y_t = \frac{Y_t}{\Gamma_{t-1}} = \frac{z_t K_t^{\alpha}(\Gamma_t l_t)^{1-\alpha}}{\Gamma_{t-1}} = z_t k_t^{1-\alpha}(g_t l_t)^{\alpha}$$

- Aggregate Resource Constraint

$$y_t = \frac{Y_t}{\Gamma_{t-1}} = \frac{C_t + I_t + B_t}{\Gamma_{t-1}} - \frac{\Gamma_t B_{t+1}}{(1+r_t)\Gamma_{t-1}\Gamma_t} = c_t + i_t + b_t - \frac{g_t b_{t+1}}{1+r_t}$$

- Current Account and Net Exports

$$\begin{aligned}
ca_t &= \frac{CA_t}{\Gamma_{t-1}} = \frac{NX_t}{\Gamma_{t-1}} = \frac{Y_t - C_t - I_t}{\Gamma_{t-1}} = \frac{B_t}{\Gamma_{t-1}} - \frac{\Gamma_t B_{t+1}}{\Gamma_{t-1}\Gamma_t}\frac{1}{1+r_t} \\
ca_t &= nx_t = y_t - c_t - i_t = b_t - g_t \frac{b_{t+1}}{1+r_t}
\end{aligned}$$

- Law of Motion of Capital

$$\begin{aligned}
g_t k_{t+1} &= \frac{\Gamma_t K_{t+1}}{\Gamma_t \Gamma_{t-1}} = \frac{(1-\delta)K_t + I_t}{\Gamma_{t-1}} - \frac{\phi}{2}\left(\frac{K_{t+1}\Gamma_t}{\Gamma_t\Gamma_{t-1}}\frac{\Gamma_{t-1}}{K_t} - \mu_g\right)^2 \frac{K_t}{\Gamma_{t-1}} \\
&= (1-\delta)k_t + i_t - \frac{\phi}{2}\left(\frac{g_t k_{t+1}}{k_t} - \mu_g\right)^2 k_t
\end{aligned}$$

- Utility Function

$$\begin{aligned}
u(C_t, 1-l_t) &= \frac{(C_t^{\gamma}(1-l_t)^{1-\gamma})^{1-\sigma}}{1-\sigma} = \frac{\Gamma_{t-1}^{\gamma(1-\sigma)}}{\Gamma_{t-1}^{\gamma(1-\sigma)}}\frac{(C_t^{\gamma}(1-l_t)^{1-\gamma})^{1-\sigma}}{1-\sigma} \\
&= \Gamma_{t-1}^{\gamma(1-\sigma)}\frac{\left(\left(\frac{C_t}{\Gamma_{t-1}}\right)^{\gamma}(1-l_t)^{1-\gamma}\right)^{1-\sigma}}{1-\sigma} \\
&= \underbrace{\Gamma_{t-1}^{\gamma(1-\sigma)}}_{\equiv \kappa_{t-1}}\underbrace{\frac{(c_t^{\gamma}(1-l_t)^{1-\gamma})^{1-\sigma}}{1-\sigma}}_{u(c_t, 1-l_t)} \\
&= \kappa_{t-1}u(c_t, 1-l_t)
\end{aligned}$$

C.1.2 Maximisation Problem of the Representative Household

We can combine the detrended versions of output, law of motion of capital, and the aggregate resource constraint to write the period budget constraint of the representative agent as

$$z_t k_t^{1-\alpha}(g_t l_t)^\alpha + (1-\delta)k_t + \frac{g_t b_{t+1}}{1+r_t} = c_t + g_t k_{t+1} + \frac{\phi}{2}\left(g_t \frac{k_{t+1}}{k_t} - \mu_g\right)^2 k_t + b_t.$$

Hence, the household's optimisation problem at time t can then be stated as

$$\max_{\{c_\tau, l_\tau, k_{\tau+1}, b_{\tau+1}\}} \mathrm{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t}(\kappa_{\tau-1} u(c_\tau, 1-l_\tau))$$

subject to

$$z_\tau k_\tau^{1-\alpha}(g_\tau l_\tau)^\alpha + (1-\delta)k_\tau + \frac{g_\tau b_{\tau+1}}{1+r_\tau} = c_\tau + g_\tau k_{\tau+1} + \frac{\phi}{2}\left(g_\tau \frac{k_{\tau+1}}{k_\tau} - \mu_g\right)^2 k_\tau + b_\tau,$$

for given k_t, b_t, and the transversality condition $\lim_{j\to\infty} \mathrm{E}_t\left(\frac{b_{t+1+j}}{\prod_{s=0}^{j}(1+r_s)}\right) = 0$.

The maximisation problem yields the following Lagrangian:

$$\begin{aligned}\mathcal{L} =& \mathrm{E}_t\left[\sum_{\tau=t}^{\infty} \beta^{\tau-t}\left(\kappa_{\tau-1} u(c_\tau, 1-l_\tau) + \lambda_\tau\left(z_\tau k_\tau^{1-\alpha}(g_\tau l_\tau)^\alpha + \frac{g_\tau b_{\tau+1}}{1+r_\tau} + (1-\delta)k_\tau \right.\right.\right. \\ & \left.\left.\left. - c_\tau - g_\tau k_{\tau+1} - \frac{\phi}{2}\left(g_\tau \frac{k_{\tau+1}}{k_\tau} - \mu_g\right)^2 k_\tau - b_\tau\right)\right)\right].\end{aligned}$$

We can then derive the first–order conditions as

$$\begin{aligned}
\text{(I)} \quad & \frac{\partial \mathcal{L}}{\partial c_t} = \kappa_{t-1}\frac{\partial u(c_t, 1-l_t)}{\partial c_t} - \lambda_t = 0 \\
& \Leftrightarrow \quad \kappa_{t-1}\frac{\partial u(c_t, 1-l_t)}{\partial c_t} = \lambda_t \\
& \Rightarrow \quad \kappa_t \mathrm{E}_t\left[\frac{\partial u(c_{t+1}, 1-l_{t+1})}{\partial c_{t+1}}\right] = \mathrm{E}_t\left[\lambda_{t+1}\right] \\
\text{(II)} \quad & \frac{\partial \mathcal{L}}{\partial l_t} = \kappa_{t-1}\frac{\partial u(c_t, 1-l_t)}{\partial l_t} + \lambda_t \frac{\partial y_t}{\partial l_t} = 0 \\
& \Leftrightarrow \quad -\kappa_{t-1}\frac{\partial u(c_t, 1-l_t)}{\partial l_t} = \lambda_t \frac{\partial y_t}{\partial l_t} \\
\text{(III)} \quad & \frac{\partial \mathcal{L}}{\partial k_{t+1}} = -\lambda_t\left[g_t\left(1 + \phi\left(g_t \frac{k_{t+1}}{k_t} - \mu_g\right)\right)\right] + \mathrm{E}_t\left[\beta\lambda_{t+1}\left(\frac{\partial y_{t+1}}{\partial k_{t+1}}\right.\right. \\
& \left.\left. + (1-\delta) + \phi\left(g_{t+1}\frac{k_{t+2}}{k_{t+1}} - \mu_g\right) g_{t+1}\frac{k_{t+2}}{k_{t+1}} - \frac{\phi}{2}\left(g_{t+1}\frac{k_{t+2}}{k_{t+1}} - \mu_g\right)^2\right)\right] = 0
\end{aligned}$$

$$\Leftrightarrow \quad \lambda_t \left[g_t \left(1 + \phi \left(g_t \frac{k_{t+1}}{k_t} - \mu_g \right) \right) \right] = \mathrm{E}_t \Big[\beta \lambda_{t+1} \Big(\frac{\partial y_{t+1}}{\partial k_{t+1}}$$

$$+ (1-\delta) + \phi \Big(g_{t+1} \frac{k_{t+2}}{k_{t+1}} - \mu_g \Big) g_{t+1} \frac{k_{t+2}}{k_{t+1}} - \frac{\phi}{2} \Big(g_{t+1} \frac{k_{t+2}}{k_{t+1}} - \mu_g \Big)^2 \Big) \Big]$$

$$\text{(IV)} \quad \frac{\partial \mathcal{L}}{\partial b_{t+1}} = \lambda_t g_t \frac{1}{1+r_t} - \beta \mathrm{E}_t \left[\lambda_{t+1} \right] = 0$$

$$\Leftrightarrow \quad \lambda_t g_t \frac{1}{1+r_t} = \beta \mathrm{E}_t \left[\lambda_{t+1} \right]$$

$$\text{(V)} \quad \frac{\partial \mathcal{L}}{\partial \lambda_t} = y_t + \frac{g_t b_{t+1}}{1+r_t} + (1-\delta) k_t - c_t - g_t k_{t+1} - \frac{\phi}{2} \left(g_t \frac{k_{t+1}}{k_t} - \mu_g \right)^2 k_t - b_t = 0$$

$$\Leftrightarrow \quad y_t + \frac{g_t b_{t+1}}{1+r_t} + (1-\delta) k_t = c_t + g_t k_{t+1} + \frac{\phi}{2} \left(g_t \frac{k_{t+1}}{k_t} - \mu_g \right)^2 k_t + b_t$$

As a result, the stationary model is described by the following optimality and necessary conditions:

- Production Function

$$y_t = z_t k_t^{\alpha} (g_t l_t)^{1-\alpha} \tag{C.1}$$

- Period t Resource Constraint

$$y_t = c_t + i_t + b_t - \frac{g_t b_{t+1}}{1+r_t} \tag{C.2}$$

- Law of Motion of Capital

$$g_t k_{t+1} = (1-\delta) k_t + i_t - \frac{\phi}{2} \left(\frac{g_t k_{t+1}}{k_t} - \mu_g \right)^2 k_t \tag{C.3}$$

- Investment Euler Equation

$$\begin{aligned} &\frac{\partial u(c_t, 1-l_t)}{\partial c_t} \left(1 + \phi \left(g_t \frac{k_{t+1}}{k_t} - \mu_g \right) \right) = g_t^{\gamma(1-\sigma)-1} \beta \mathrm{E}_t \Big[\frac{\partial u(c_{t+1}, 1-l_{t+1})}{\partial c_{t+1}} \\ &\Big(\frac{\partial y_{t+1}}{\partial k_{t+1}} + (1-\delta) + \phi \Big(g_{t+1} \frac{k_{t+2}}{k_{t+1}} - \mu_g \Big) g_{t+1} \frac{k_{t+2}}{k_{t+1}} - \frac{\phi}{2} \Big(g_{t+1} \frac{k_{t+2}}{k_{t+1}} - \mu_g \Big)^2 \Big) \Big] \end{aligned} \tag{C.4}$$

- Labour–Leisure Trade–off

$$-\frac{\partial u(c_t, 1-l_t)}{\partial l_t} = \frac{\partial u(c_t, 1-l_t)}{\partial c_t} \frac{\partial y_t}{\partial l_t} \tag{C.5}$$

- Bond Euler Equation

$$\frac{\partial u(c_t, 1-l_t)}{\partial c_t} = g_t^{\gamma(1-\sigma)-1} \beta \mathrm{E}_t \left[\frac{\partial u(c_{t+1}, 1-l_{t+1})}{\partial c_{t+1}} (1+r_t) \right] \tag{C.6}$$

- Interest Rate

$$1 + r_t = R_t^\star + \psi \left(\exp \left(b_{t+1} - b \right) - 1 \right) \tag{C.7}$$

- Current Account and Net Exports

$$ca = nx = y - c - i = b_t - g_t \frac{b_{t+1}}{1+r_t} \tag{C.8}$$

- Transitory Technology Process

$$z_{t+1} = z_t^{\rho_z} \exp(\epsilon_{t+1}^z) \tag{C.9}$$

- Permanent Technology Process

$$g_{t+1} = \mu_g^{1-\rho_g} g_t^{\rho_g} \exp(\epsilon_{t+1}^g) \tag{C.10}$$

- World Interest Rate Process

$$R_{t+1}^\star = (R^\star)^{1-\rho_R} (R_t^\star)^{\rho_R} \exp(\epsilon_{t+1}^R) \tag{C.11}$$

Moreover, note that

$$\begin{aligned}
\frac{\partial u(c_t, 1-l_t)}{\partial c_t} &= \frac{\gamma (c_t^\gamma (1-l_t)^{1-\gamma})^{1-\sigma}}{c_t} \\
\frac{\partial u(c_t, 1-l_t)}{\partial l_t} &= -\frac{(1-\gamma)(c_t^\gamma (1-l_t)^{1-\gamma})^{1-\sigma}}{(1-l_t)} \\
\frac{\partial y_t}{\partial k_t} &= \alpha \frac{y_t}{k_t} \\
\frac{\partial y_t}{\partial l_t} &= (1-\alpha) \frac{y_t}{l_t}
\end{aligned}$$

C.1.3 Steady States

Steady state conditions are given by

$$z = 1$$

$$g = \mu_g$$

$$r = \mu_g^{1-\gamma(1-\sigma)} \frac{1}{\beta} - 1$$

$$R^\star = 1 + r$$

$$\frac{k}{y} = \frac{\alpha}{r + \delta}$$

$$\frac{c}{y} = 1 + (1 - \delta - \mu_g)\frac{k}{y} + \left(\frac{\mu_g}{1+r} - 1\right)\frac{b}{y}$$

$$l = \left(1 + \frac{1-\gamma}{\gamma(1-\alpha)}\frac{c}{y}\right)^{-1}$$

$$k = \left(\frac{k}{y}\right)^{\frac{1}{1-\alpha}} l\mu_g$$

$$y = \frac{y}{k}k$$

$$c = \frac{c}{y}y$$

$$b = \frac{b}{y}y$$

$$i = k(\mu_g - 1 + \delta)$$

$$ca = nx = y - c - i$$

C.1.4 Solving the Model

Finally, we end up with a stationary system of 11 non–linear difference equations (C.1) – (C.11) in 11 variables. The model features 3 exogenous state variables, 2 endogenous state variables, and 6 control variables:

- Vector of exogenous state variables:
  $\mathbf{x}_{x,t} = \begin{bmatrix} z_t & g_t & R_t^\star \end{bmatrix}'$

- Vector of endogenous state variables:
  $\mathbf{x}_{e,t} = [k_t \quad b_t]'$

- Vector of control variables:
  $\mathbf{x}_{c,t} = [y_t \quad c_t \quad i_t \quad l_t \quad r_t \quad ca_t]'$.

Unfortunately, the model does not have a closed form solution. Therefore, we have to approximate its solution. We do so by log–linearising the system around its deterministic steady state. Subsequently, we solve the resulting linear system of expectational difference equations using the methodology suggested by Klein (2000). Section A.1.6 of Appendix A describes this approach in detail.

Finally, we can express the model in state space form:

- *Measurement Equation*

$$\widehat{\mathbf{x}}_{c,t} = \mathbf{Z}\,\widehat{\mathbf{x}}_{s,t}$$

- *Transition Equation*

$$\widehat{\mathbf{x}}_{s,t} = \mathbf{T}\,\widehat{\mathbf{x}}_{s,t-1} + \mathbf{R}\boldsymbol{\epsilon}_t, \qquad \boldsymbol{\epsilon}_t \sim \mathcal{N}(\mathbf{0}, \boldsymbol{\Sigma})$$

  with

$$\mathbf{R} = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

$$\boldsymbol{\epsilon}_t = \begin{pmatrix} \epsilon_t^z \\ \epsilon_t^g \\ \epsilon_t^R \end{pmatrix}$$

$$\boldsymbol{\Sigma} = \begin{pmatrix} \sigma_z^2 & 0 & 0 \\ 0 & \sigma_g^2 & 0 \\ 0 & 0 & \sigma_R^2 \end{pmatrix}.$$

C.2 Global versus Country–Specific Shocks

This section shows how we use the QR decomposition to identify country–specific productivity shocks and global interest rate shocks.

Reconsider matrix $\mathbf{P} = [\mathbf{\Sigma}\boldsymbol{\alpha}_{\perp}\mathbf{S}_{\pi} \quad \boldsymbol{\alpha}\mathbf{S}_{\tau}]$, which maps mutually orthogonal permanent and transitory shocks into reduced form shocks. In our trivariate system, matrix $\mathbf{P}$ takes the general form

$$\mathbf{P} = \begin{pmatrix} p_{11} & p_{12} & p_{13} \\ p_{21} & p_{22} & p_{23} \\ p_{31} & p_{32} & p_{33} \end{pmatrix}.$$

Our ordering of shocks implies that impact responses to transitory shocks are summarised in the last two columns of $\mathbf{P}$, which is the (3×2) matrix $\boldsymbol{\alpha}\mathbf{S}_{\tau}$. We can distinguish global from country–specific temporary shocks by imposing a restriction on $\boldsymbol{\alpha}\mathbf{S}_{\tau}$, such that it takes the form

$$\boldsymbol{\alpha}\mathbf{S}_{\tau} = \begin{pmatrix} \star & 0 \\ \star & \star \\ \star & \star \end{pmatrix}.$$

Consider now the following partition of matrix $\boldsymbol{\alpha}\mathbf{S}_{\tau}$. Define matrix $\mathbf{A}$ as the upper (2×2) part of $\boldsymbol{\alpha}\mathbf{S}_{\tau}$ and $\mathbf{B}$ as the lower (1×2) part of $\boldsymbol{\alpha}\mathbf{S}_{\tau}$. That is,

$$\mathbf{A} = \begin{pmatrix} p_{12} & p_{13} \\ p_{22} & p_{23} \end{pmatrix} \quad \text{and} \quad \mathbf{B} = \begin{pmatrix} p_{32} & p_{33} \end{pmatrix},$$

such that $\boldsymbol{\alpha}\mathbf{S}_{\tau} = [\mathbf{A} \quad \mathbf{B}]'$. Since our transitory components are already orthogonal, any orthogonal decomposition of (parts of) matrix $\boldsymbol{\alpha}\mathbf{S}_{\tau}$ preserves the orthogonality of shocks. Recall, any square matrix can be decomposed into $\mathbf{QR}$, where $\mathbf{Q}$ is an orthogonal matrix and $\mathbf{R}$ is an upper triangular matrix. Hence, we can take a QR decomposition of matrix $\mathbf{A}'$, such that $\mathbf{A} = \mathbf{R}'\mathbf{Q}'$, where $\mathbf{R}'$ is a lower triangular matrix and $\mathbf{Q}'$ is an orthogonal matrix. We can then rewrite $\boldsymbol{\alpha}\mathbf{S}_\tau$ as follows

$$\begin{aligned}
\boldsymbol{\alpha}\mathbf{S}_\tau &= \begin{pmatrix} \mathbf{R}'\mathbf{Q}' \\ \mathbf{B} \end{pmatrix} = \begin{pmatrix} \begin{pmatrix} r_{11} & 0 \\ r_{12} & r_{22} \end{pmatrix} \begin{pmatrix} q_{11} & q_{21} \\ q_{12} & q_{22} \end{pmatrix} \\ \mathbf{B} \end{pmatrix} \\
\Leftrightarrow \qquad \boldsymbol{\alpha}\mathbf{S}_\tau\mathbf{Q} &= \begin{pmatrix} \begin{pmatrix} r_{11} & 0 \\ r_{12} & r_{22} \end{pmatrix} \mathbf{Q}'\mathbf{Q} \\ \mathbf{B}\mathbf{Q} \end{pmatrix} = \begin{pmatrix} \begin{pmatrix} r_{11} & 0 \\ r_{12} & r_{22} \end{pmatrix} \mathbf{I}_2 \\ \mathbf{B}\mathbf{Q} \end{pmatrix} \\
\Leftrightarrow \qquad \boldsymbol{\alpha}\mathbf{S}_\tau\mathbf{Q} &= \begin{pmatrix} r_{11} & 0 \\ r_{12} & r_{22} \\ p_{32}q_{11} + p_{33}q_{21} & p_{32}q_{12} + p_{33}q_{22} \end{pmatrix}.
\end{aligned}$$

As a result, we obtain an adjusted matrix $\widetilde{\mathbf{P}} = [\boldsymbol{\Sigma}\boldsymbol{\alpha}_\perp\mathbf{S}_\pi \quad \boldsymbol{\alpha}\mathbf{S}_\tau\mathbf{Q}]$ of the form

$$\widetilde{\mathbf{P}} = \begin{pmatrix} \star & \star & 0 \\ \star & \star & \star \\ \star & \star & \star \end{pmatrix},$$

which maps our structural shocks into reduced form disturbances:

$$\widetilde{\mathbf{P}}\boldsymbol{\Theta}_t = \widetilde{\mathbf{P}} \begin{pmatrix} \pi_t \\ \tau_t^g \\ \tau_t^c \end{pmatrix} = \boldsymbol{\epsilon}_t.$$

C.3 Impulse Responses

Empirical Impulse Responses

This section presents the impulse responses of the current account to output ratio and income to the three identified shocks. Figures C.1 to C.5 show the impulse responses of $\frac{CA}{Y}$ and y to a positive permanent shock. Impulse responses of these two variables to global and country–specific transitory shocks are displayed in Figures C.6 to C.10 and C.11 to C.15, respectively.

Figure C.1: Impulse Responses – Permanent Shock I

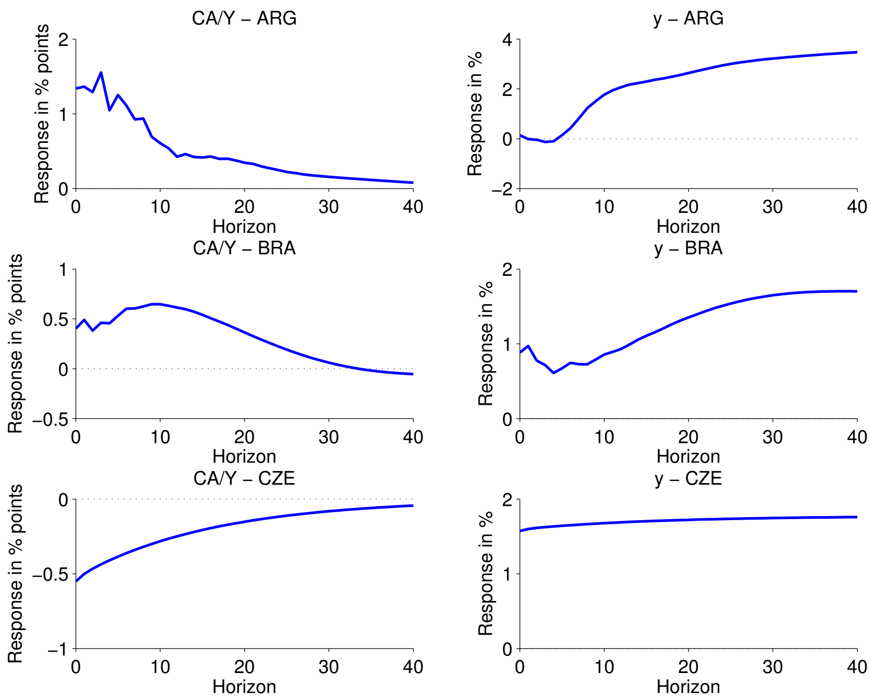


Figure C.2: Impulse Responses – Permanent Shock II

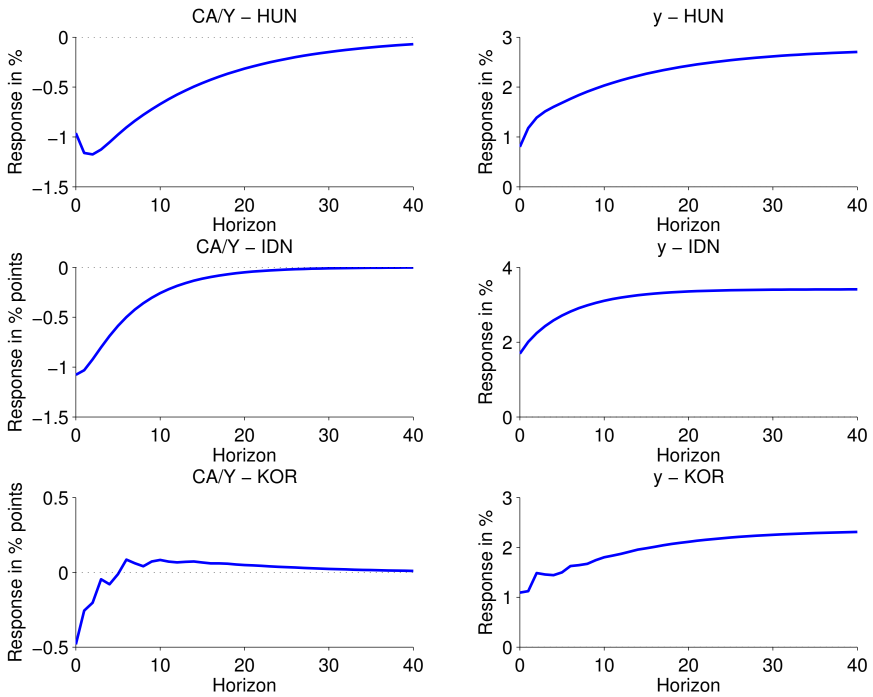


Figure C.3: Impulse Responses – Permanent Shock III

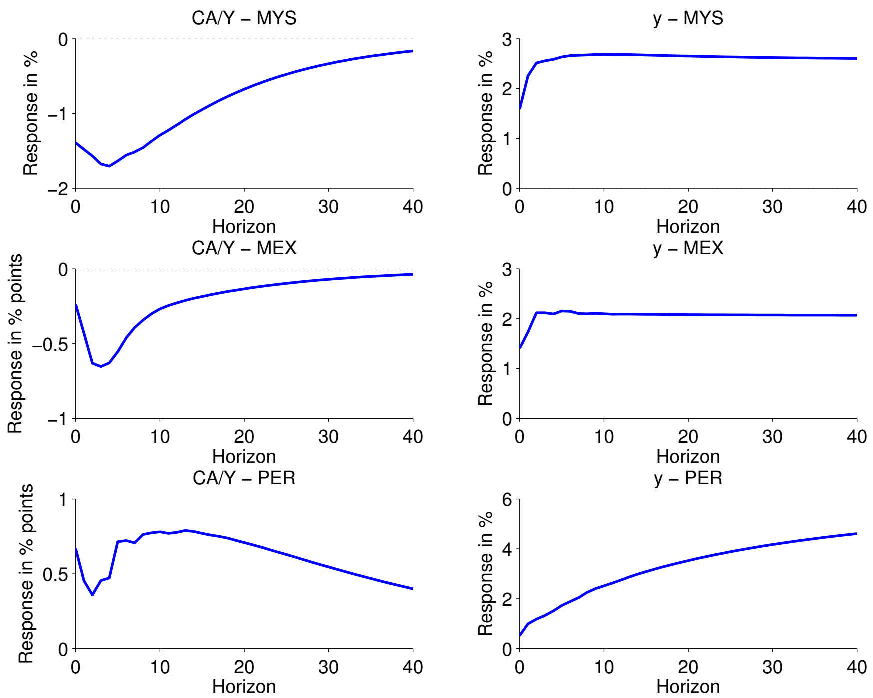


Figure C.4: Impulse Responses – Permanent Shock IV

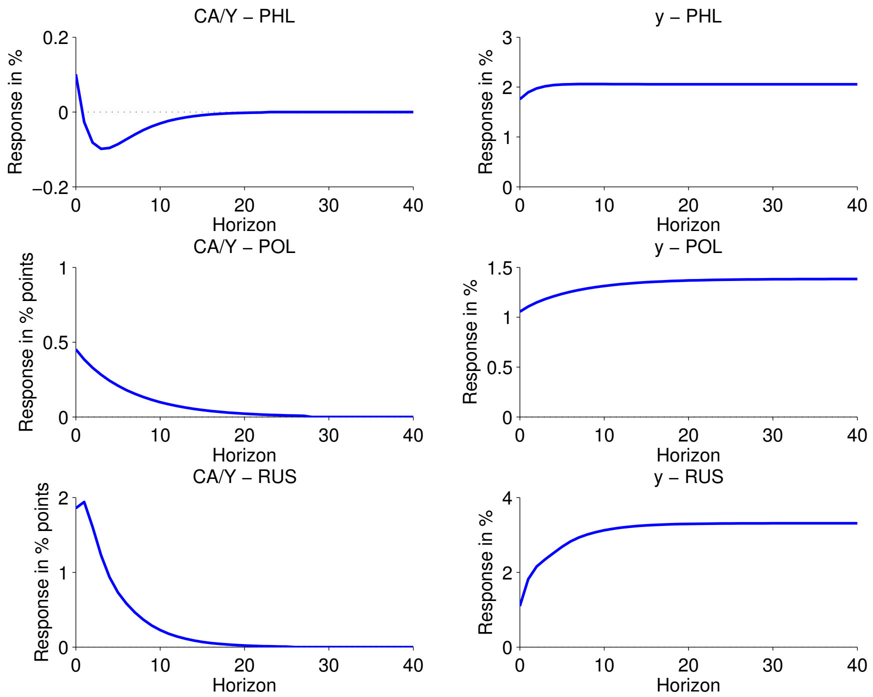


Figure C.5: Impulse Responses – Permanent Shock V

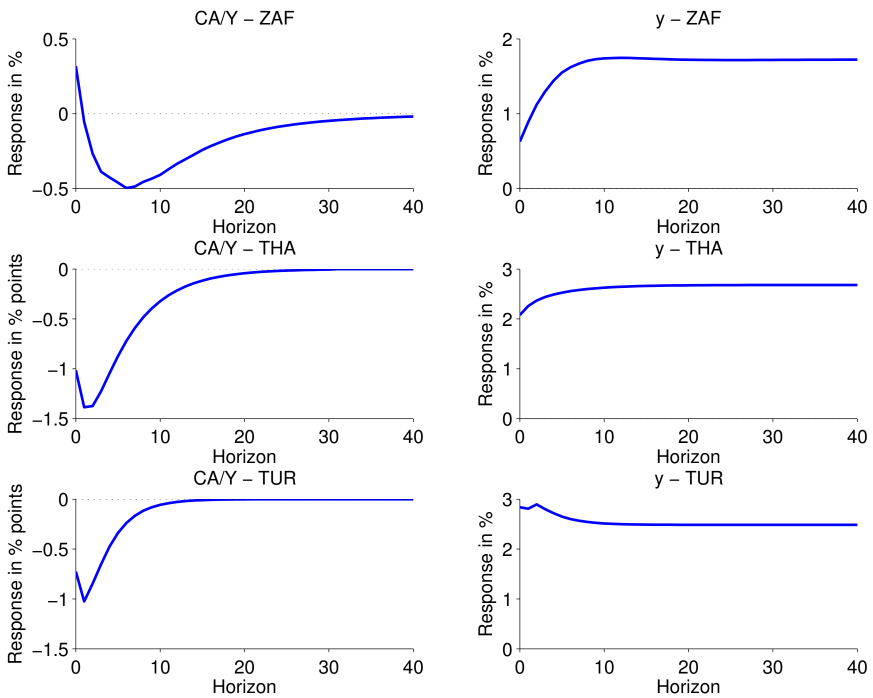


Figure C.6: Impulse Responses – Global Transitory Shock I

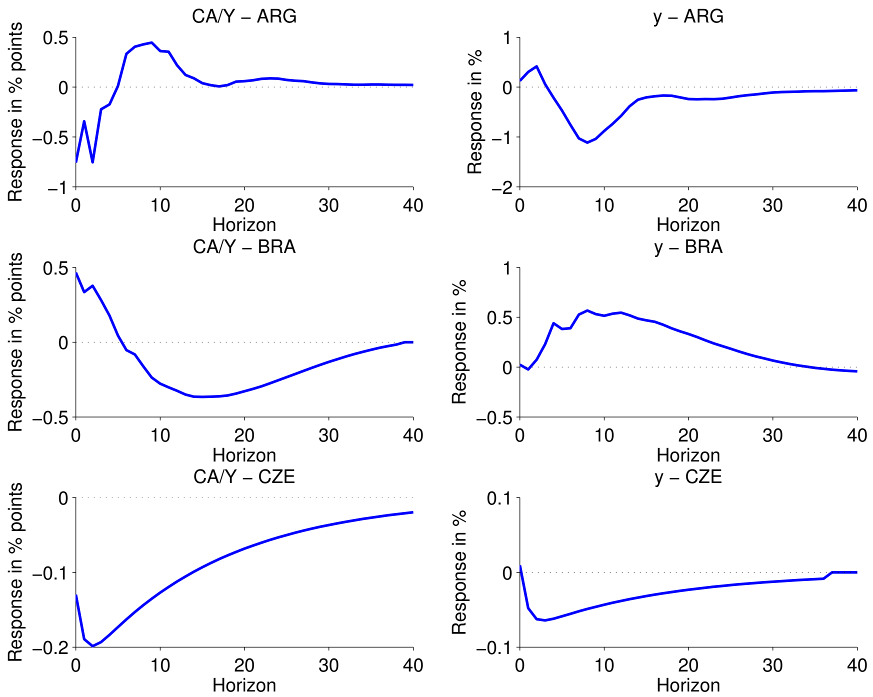


Figure C.7: Impulse Responses – Global Transitory Shock II

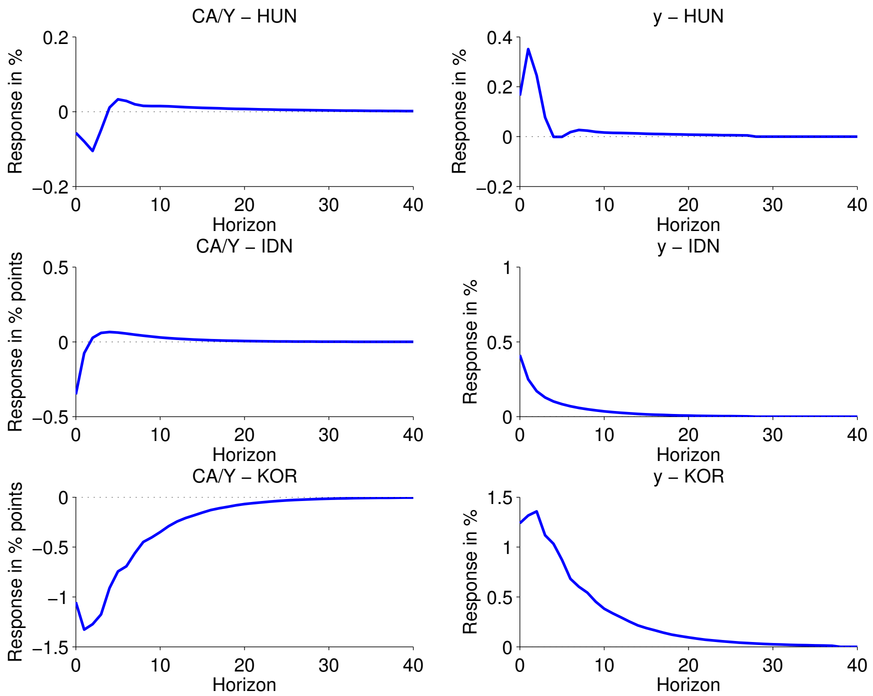


Figure C.8: Impulse Responses – Global Transitory Shock III

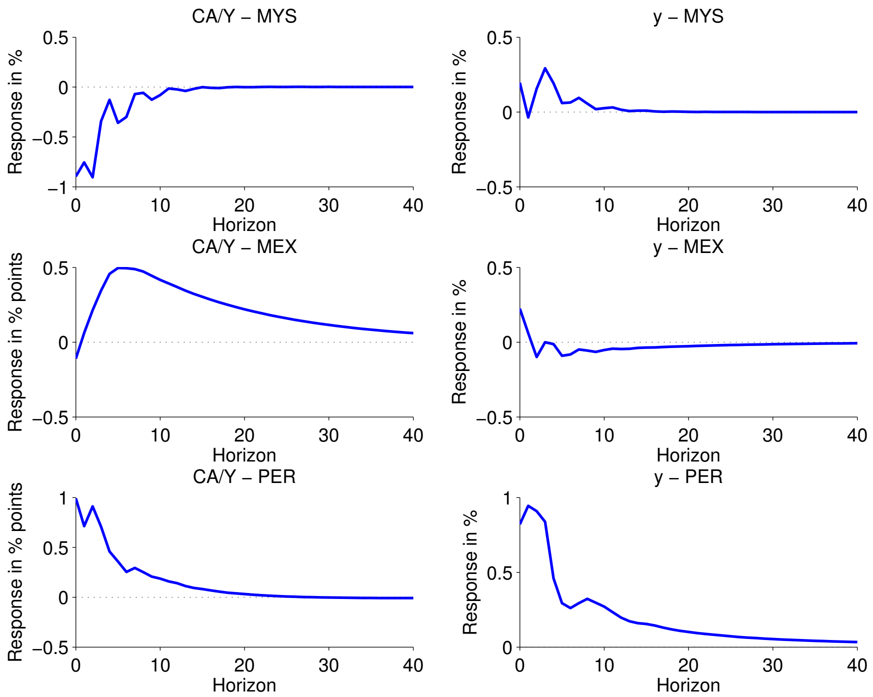


Figure C.9: Impulse Responses – Global Transitory Shock IV

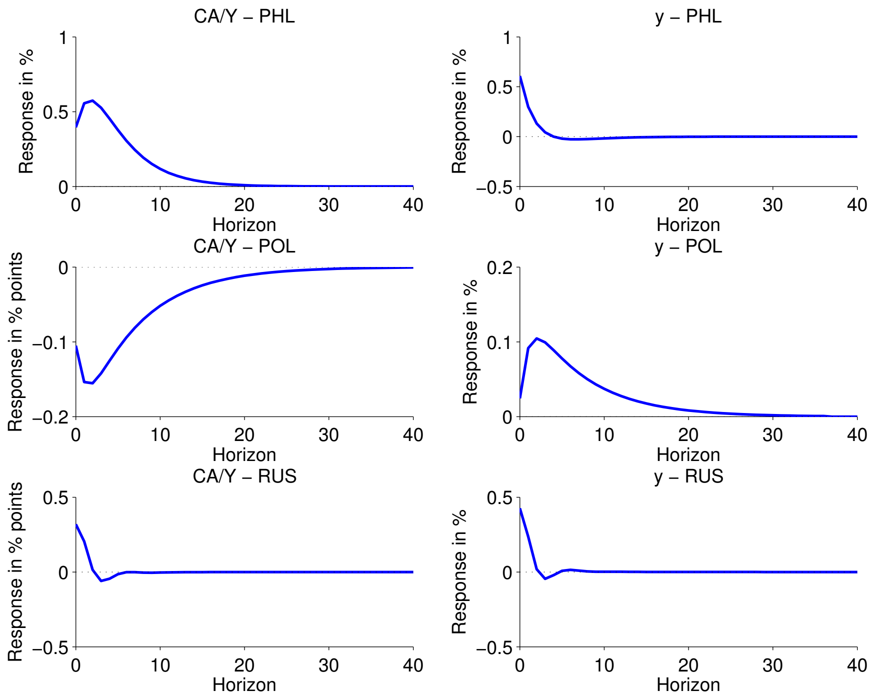


Figure C.10: Impulse Responses – Global Transitory Shock V

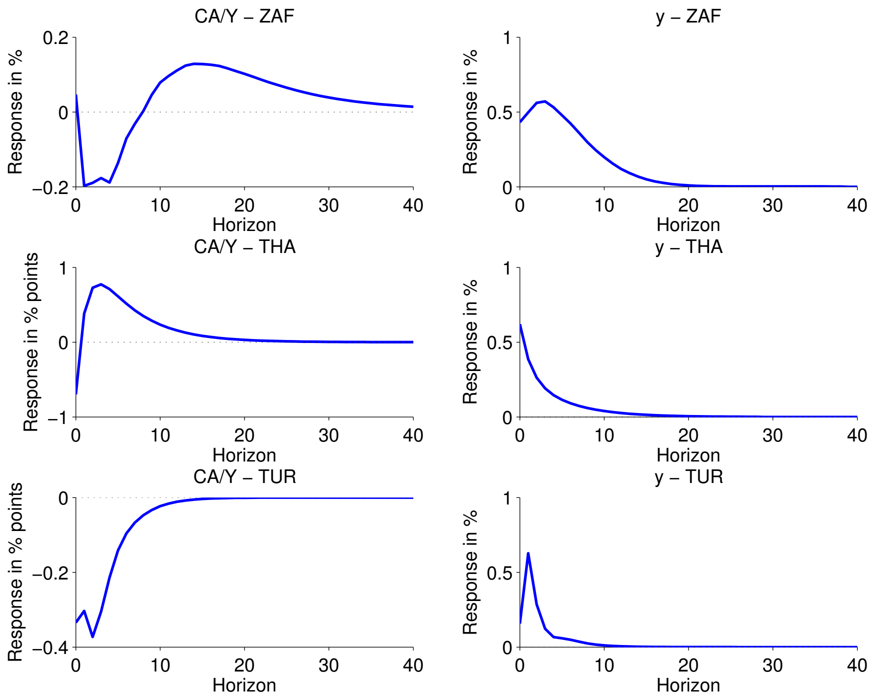


Figure C.11: Impulse Responses – Country–Specific Transitory Shock I

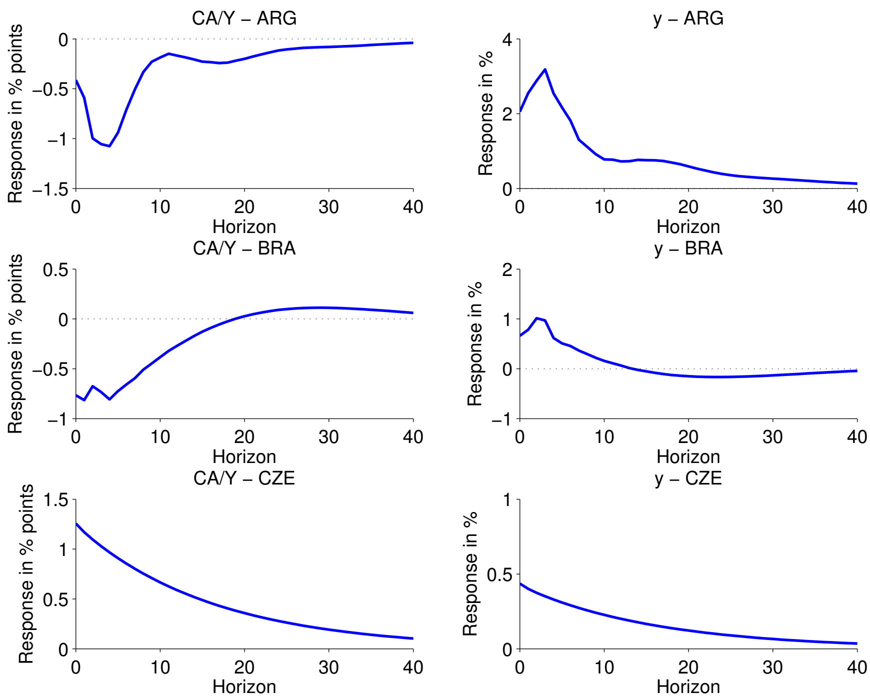


Figure C.12: Impulse Responses – Country–Specific Transitory Shock II

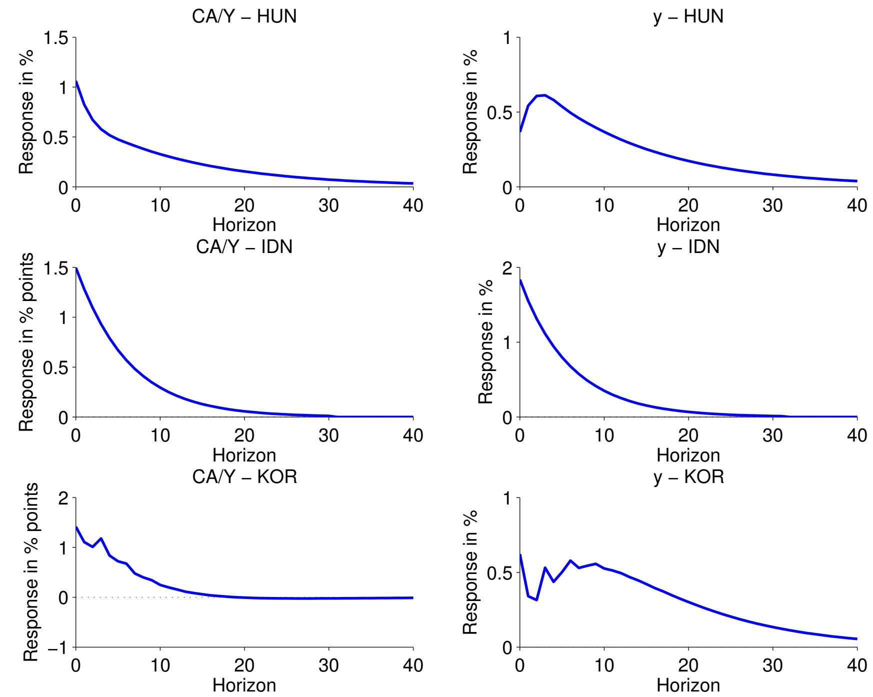


Figure C.13: Impulse Responses – Country–Specific Transitory Shock III

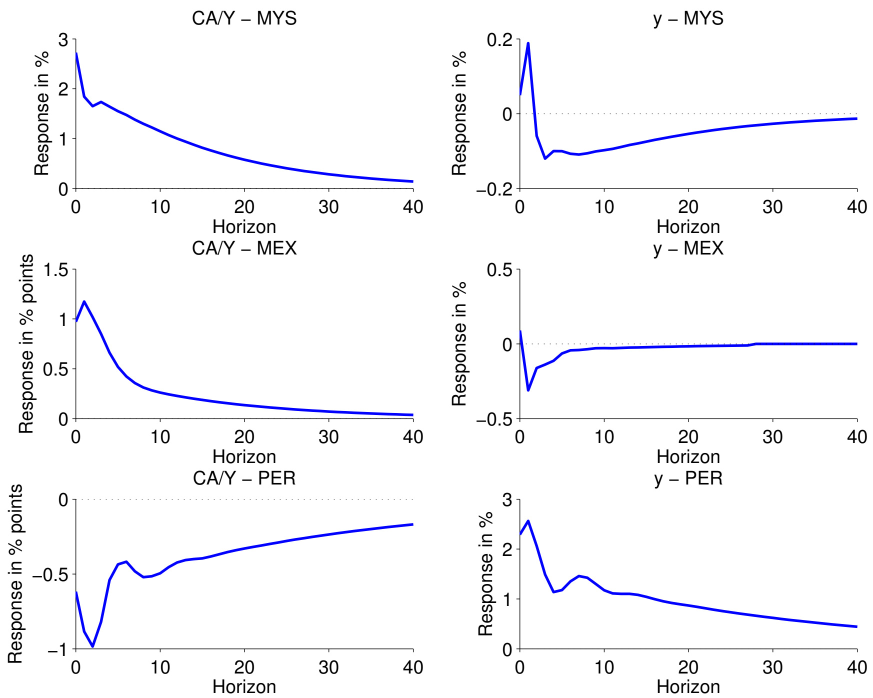


Figure C.14: Impulse Responses – Country–Specific Transitory Shock IV

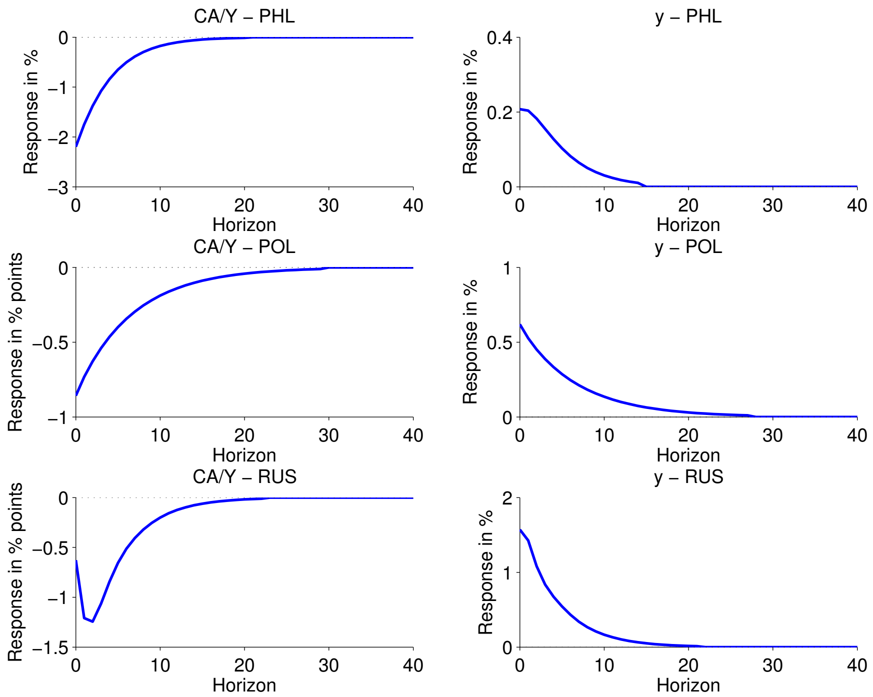
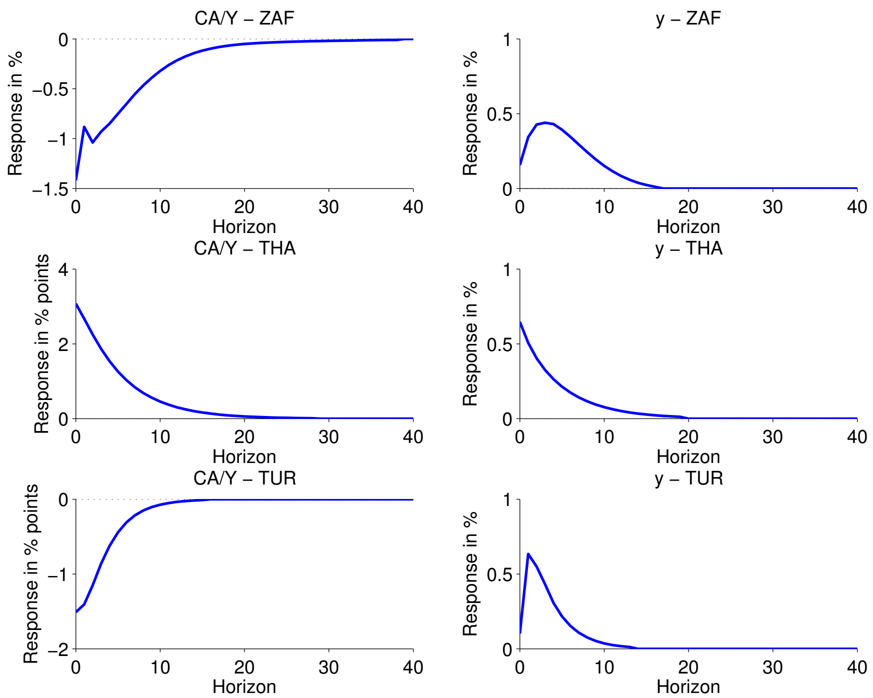


Figure C.15: Impulse Responses – Country–Specific Transitory Shock V



Theoretical Impulse Responses

Figure C.16 shows the model implied impulse responses of the current account to output ratio and income to a permanent productivity shock for different values of ρ_g. To facilitate comparison with our baseline calibration, we use the same parameter values as reported in Table 4.1 but vary the persistence of the non–stationary technology process ρ_g.

The intuition for the impulse responses of $\frac{CA}{Y}$ and y in Figure C.16 are described in the main text of Chapter 4. Note that variable y in the DSGE model is not equivalent to y in our VECM. As we know, variable y corresponds to detrended output in the theoretical model, i.e. $y_t = \frac{Y_t}{\Gamma_{t-1}}$, whereas it denotes the log of real per capita GDP in the VECM. That is the reason why the effect of a permanent shock on y will eventually die out in the DSGE model. By contrast, we observe a long–run change of y in the empirical impulse responses above.

Figure C.16: Theoretical Impulse Responses – Permanent Shock with Different ρ_g

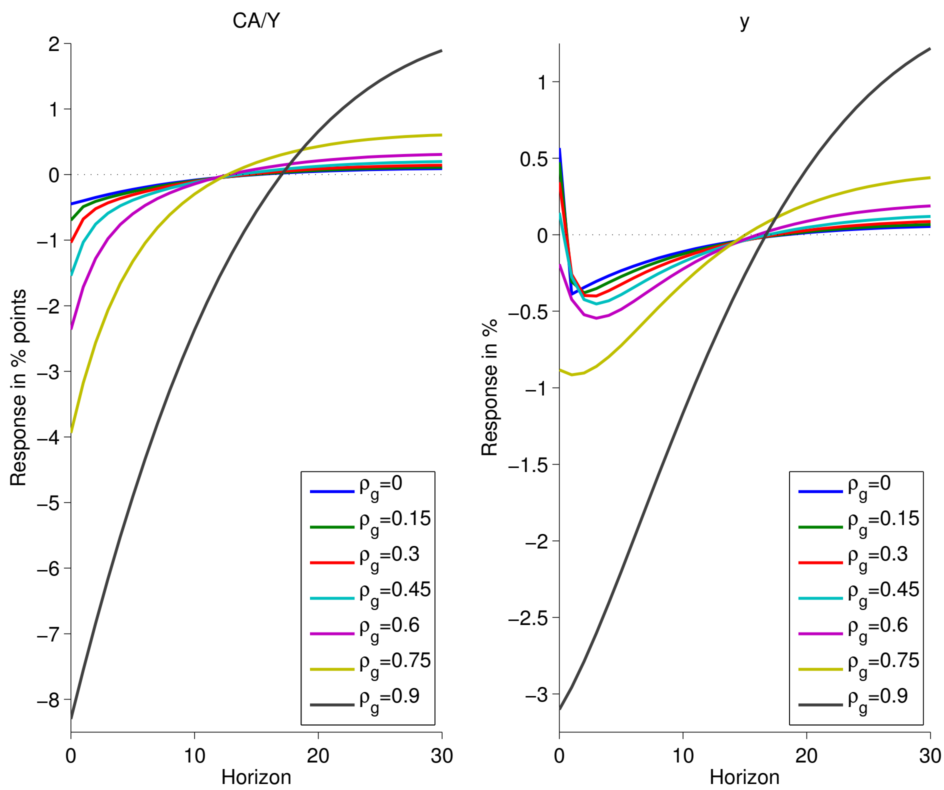


Figure C.17 displays the impulse responses of $\frac{CA}{Y}$ and y to a transitory productivity shock in the model augmented with a country spread. We use the same parametrisation as before, but let the parameter on the interest rate premium η take on different values. Recall that the interest rate rule including the spread term is given by

$$1 + r_t = R_t^\star + \psi\left(\exp\left(b_{t+1} - b\right) - 1\right) - \eta\left(\exp\left(\mathrm{E}_t\left[z_{t+1}\right] - z\right) - 1\right).$$

As a result, parameter η approximately shows by how many percentage points the interest rate r_t decreases if we expect tomorrow's stationary TFP component z_{t+1} to increase by 1 percent.[1]

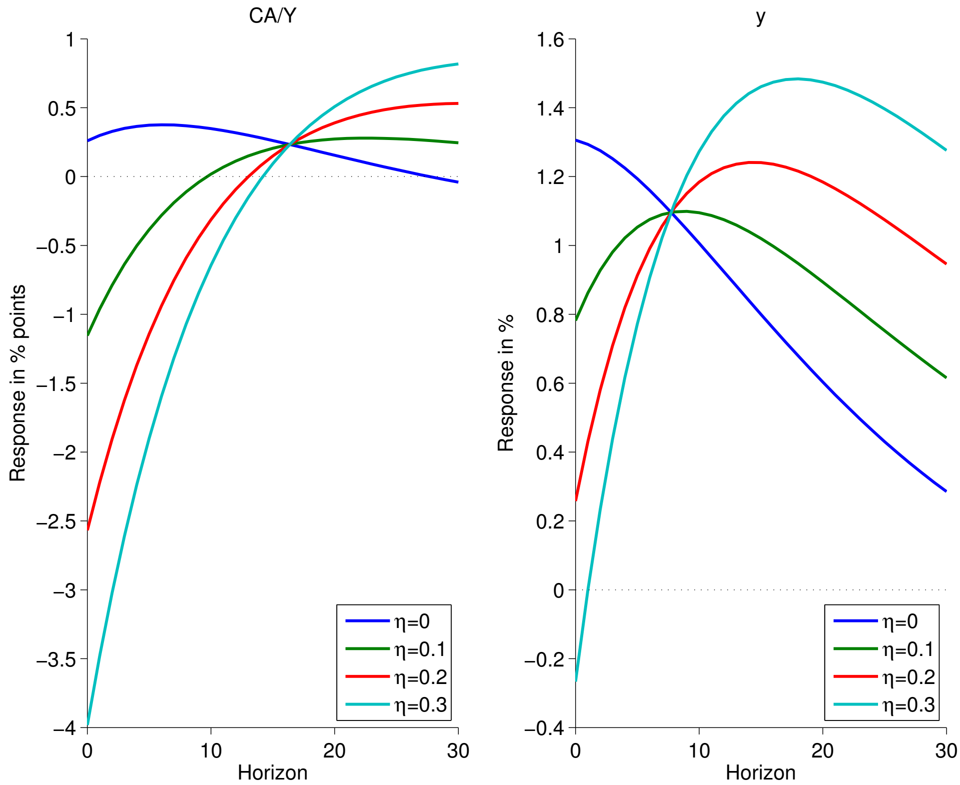
As η increases, the impact of the transitory productivity shock on consumption and investment becomes more and more amplified. Hence, for a sufficiently large η, the response of the current account to output ratio is actually negative. Interestingly, a higher value of η also implies a weaker increase in output. In fact, if η is large enough, output actually decreases initially. The intuition behind this prediction of the model is similar to the effect of a highly persistent trend shock. The decline in the interest rate premium entails a positive income effect, which creates an incentive to work less. If this income effect on labour supply is large enough, the decrease in labour input outweighs the positive effect of the productivity shock, such that output falls on impact.

[1]Take a look at the interest rate rule in log–linear form, which is given by

$$\begin{aligned} & r\widehat{r_t} = R^\star \widehat{R_t^\star} + \psi b\widehat{b_{t+1}} - \eta z \mathrm{E}_t\left[\widehat{z_{t+1}}\right] \\ \Leftrightarrow \quad & \mathrm{d}r_t \approx \mathrm{d}R_t^\star + \psi \mathrm{d}b_{t+1} - \eta \mathrm{d}\mathrm{E}_t\left[z_{t+1}\right]. \end{aligned}$$

Hence, since $\mathrm{d}R_t^\star = 0$ (world interest rate is exogenous) and for $\psi \mathrm{d}b_{t+1} = 0$ (which is basically always fulfilled since ψ is close to zero), we have $\mathrm{d}r_t / \mathrm{d}\mathrm{E}_t\left[z_{t+1}\right] \approx -\eta$.

Figure C.17: Theoretical Impulse Responses – Transitory Shock with Different η



C.4 Forecast Error Variance Decomposition

The table below shows the percentage share of the forecast error variance explained by permanent, global transitory, and country–specific transitory shocks at forecast horizons of 0, 4, 8, 20, and 40 quarters for each country. Thus, it complements Table 9 in the main text, which presents contemporaneous FEVD.

			$r^\star$			$\frac{CA}{Y}$			y	
	Horizon	π	τ^g	τ^c	π	τ^g	τ^c	π	τ^g	τ^c
	0	24.59	75.41	0.00	70.65	22.63	6.72	0.44	0.37	99.19
	4	22.52	74.33	3.15	63.26	9.61	27.13	0.13	0.91	98.96
ARG	8	24.83	70.70	4.48	64.54	8.69	26.77	4.62	6.53	88.84
	20	27.18	67.34	5.48	65.58	9.56	24.85	50.90	5.42	43.68
	40	27.75	66.59	5.66	65.93	9.42	24.65	81.09	2.15	16.76
	0	37.12	62.88	0.00	16.88	22.47	60.65	63.98	0.05	35.97
	4	39.00	59.14	1.86	21.80	13.09	65.12	46.78	3.69	49.53
BRA	8	40.64	57.60	1.76	31.82	8.30	59.87	50.16	10.95	38.89
	20	40.74	57.12	2.14	45.70	15.06	39.24	70.84	13.73	15.43
	40	40.64	56.87	2.49	44.94	17.85	37.21	89.19	5.15	5.66
	0	2.75	97.25	0.00	15.98	0.89	83.14	92.86	0.00	7.13
	4	2.80	93.00	4.20	15.20	2.20	82.60	94.62	0.10	5.28
CZE	8	3.27	89.48	7.25	15.06	2.44	82.49	95.72	0.10	4.18
	20	3.78	85.58	10.63	14.98	2.59	82.42	97.55	0.07	2.38
	40	3.92	84.60	11.48	14.97	2.62	82.41	98.70	0.04	1.27
	0	0.11	99.89	0.00	44.95	0.16	54.89	79.94	3.37	16.69
	4	1.61	96.49	1.90	67.65	0.26	32.09	83.61	2.06	14.34
HUN	8	3.26	94.54	2.20	71.57	0.20	28.23	89.14	0.89	9.97
	20	4.82	92.64	2.54	73.70	0.16	26.14	95.79	0.26	3.96
	40	5.10	92.30	2.60	73.99	0.16	25.85	98.30	0.10	1.60
	0	18.16	81.84	0.00	32.96	3.50	63.54	44.72	2.64	52.64
	4	17.34	82.33	0.33	38.43	1.26	60.31	71.19	0.84	27.98
IDN	8	17.39	82.12	0.48	39.19	1.14	59.66	83.13	0.44	16.42
	20	17.42	82.04	0.54	39.42	1.11	59.47	93.76	0.16	6.08
	40	17.42	82.04	0.54	39.42	1.11	59.47	97.14	0.07	2.79
	0	50.63	49.37	0.00	6.95	33.12	59.93	38.26	49.32	12.42
	4	50.25	42.81	6.93	2.60	50.06	47.34	51.03	42.78	6.19
KOR	8	48.85	39.21	11.94	2.21	50.58	47.21	62.48	30.25	7.26
	20	47.35	35.69	16.97	2.39	51.30	46.31	81.66	12.65	5.69
	40	47.10	35.17	17.73	2.47	51.27	46.26	91.63	5.59	2.78

MYS	0	5.41	94.59	0.00	19.05	7.90	73.05	98.41	1.50	0.10
	4	8.47	91.22	0.31	36.32	6.86	56.82	99.08	0.68	0.24
	8	8.48	90.51	1.01	42.13	4.93	52.94	99.43	0.37	0.20
	20	9.61	88.06	2.33	46.49	3.49	50.02	99.72	0.15	0.13
	40	10.00	87.34	2.66	47.20	3.27	49.53	99.85	0.07	0.07
MEX	0	21.19	78.81	0.00	5.49	1.21	93.30	97.13	2.48	0.39
	4	24.70	73.35	1.94	22.95	6.11	70.94	98.78	0.35	0.88
	8	24.08	72.00	3.92	25.65	15.26	59.09	99.30	0.23	0.47
	20	23.69	70.31	6.01	24.92	23.75	51.33	99.68	0.12	0.20
	40	23.62	69.94	6.44	24.74	25.38	49.89	99.83	0.06	0.10
PER	0	71.37	28.63	0.00	24.74	54.21	21.05	4.38	10.90	84.73
	4	70.96	26.76	2.27	16.50	41.32	42.19	22.60	11.18	66.22
	8	71.86	25.26	2.88	31.16	31.66	37.18	42.34	6.88	50.79
	20	73.28	23.13	3.59	51.89	17.90	30.21	74.91	2.30	22.79
	40	73.80	22.22	3.98	60.39	13.14	26.47	90.18	0.77	9.04
PHL	0	16.58	83.42	0.00	0.20	3.14	96.66	88.19	10.58	1.23
	4	16.77	81.92	1.31	0.28	9.85	89.86	96.72	2.46	0.81
	8	16.69	81.43	1.89	0.39	11.32	88.30	98.18	1.32	0.50
	20	16.67	81.34	1.99	0.41	11.56	88.03	99.23	0.55	0.21
	40	16.67	81.34	1.99	0.41	11.56	88.03	99.61	0.28	0.11
POL	0	0.09	99.91	0.00	21.51	1.16	77.33	74.37	0.04	25.59
	4	0.25	98.89	0.86	20.90	3.30	75.80	84.86	0.49	14.64
	8	0.36	98.38	1.26	20.80	3.68	75.52	90.21	0.38	9.41
	20	0.41	98.16	1.43	20.76	3.81	75.43	95.84	0.17	3.99
	40	0.41	98.15	1.44	20.76	3.81	75.43	97.97	0.08	1.94
RUS	0	0.42	99.58	0.00	87.44	2.58	9.98	31.24	4.71	64.05
	4	10.18	88.88	0.94	69.31	0.85	29.84	74.81	0.86	24.33
	8	10.33	88.66	1.00	67.84	0.76	31.40	87.43	0.39	12.18
	20	10.34	88.66	1.01	67.61	0.74	31.64	95.79	0.13	4.08
	40	10.34	88.66	1.01	67.61	0.74	31.64	98.06	0.06	1.88
ZAF	0	49.53	50.47	0.00	4.79	0.10	95.11	65.11	30.82	4.06
	4	49.74	49.47	0.79	8.32	2.36	89.33	75.03	16.44	8.53
	8	48.52	50.63	0.85	16.53	1.97	81.50	84.48	9.92	5.60
	20	48.27	50.70	1.02	23.67	3.09	73.24	94.06	3.80	2.14
	40	48.31	50.60	1.09	24.10	3.54	72.36	97.10	1.85	1.05
THA	0	20.55	79.45	0.00	9.39	4.44	86.17	84.32	7.52	8.16
	4	19.37	78.77	1.85	19.97	6.08	73.95	94.20	2.29	3.51
	8	19.45	78.00	2.56	21.20	7.32	71.48	96.72	1.25	2.03
	20	19.47	77.79	2.73	21.46	7.60	70.95	98.68	0.50	0.82
	40	19.47	77.79	2.73	21.46	7.60	70.94	99.35	0.25	0.40

	0	0.47	99.53	0.00	18.06	3.83	78.12	99.57	0.30	0.13
TUR	4	0.63	98.56	0.80	29.02	4.75	66.24	96.32	1.26	2.42
	8	0.63	98.56	0.80	29.34	4.81	65.85	97.64	0.77	1.59
	20	0.63	98.56	0.80	29.36	4.82	65.82	98.87	0.37	0.76
	40	0.63	98.56	0.80	29.36	4.82	65.82	99.39	0.20	0.41

C.5 Estimated Cointegrating Matrix

This section presents the results of our analysis if we do not impose but estimate the cointegrating matrix $\boldsymbol{\beta}$. If the cointegrating matrix is not known we cannot estimate our VECM using LS. In this case, we use Maximum Likelihood (ML) to estimate the normalised cointegrating matrix $\boldsymbol{\beta} = \begin{bmatrix} 1 & 0 & \beta_1 \\ 0 & 1 & \beta_2 \end{bmatrix}'$. Country estimates of the cointegrating matrix are reported in Table C.2. The table also presents the results of the test of the joint hypothesis $\beta_1 = \beta_2 = 0$ in each country.

Table C.2: Cointegration Estimation

	β_1	β_2	LR	p–value
ARG	0.004	0.109	7.638	0.022**
BRA	0.041	0.014	13.721	0.001***
CZE	0.023	−0.248	31.151	0.000***
HUN	0.021	0.035	14.178	0.001***
IDN	0.007	−0.027	5.294	0.071*
KOR	0.003	−0.053	7.085	0.029**
MYS	0.017	−0.188	2.710	0.260
MEX	0.035	0.103	4.719	0.095*
PER	0.005	−0.148	0.722	0.670
PHL	0.019	0.025	7.308	0.026**
POL	0.020	−0.080	11.660	0.003***
RUS	0.014	−0.015	17.882	0.000***
ZAF	0.016	0.069	1.109	0.547
THA	0.022	0.128	10.622	0.005***
TUR	0.016	0.049	13.552	0.001***
Median	0.017	0.014		
Mean	0.017	−0.015		
Std Dev	0.011	0.111		

Notes: LR denotes the Likelihood Ratio test statistic for the joint null hypothesis $H_0 : \beta_1 = \beta_2 = 0$. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table C.3 shows the impact responses of the net exports to GDP ratio as well as income to the various shocks. If we compare these impact responses to our results reported in the paper, we observe that the patterns of current account dynamics do not change for most countries. Qualitatively, the reaction of the current account to permanent and idiosyncratic transitory shocks changes only in the Czech Republic and Korea. Our key finding that the countercyclicality is either driven by trend shocks or country–specific transitory shocks survives, too. Only Malaysia and, as before, Turkey exhibit a negative response of $\frac{CA}{Y}$ to these two types of shocks once we base our analysis on an estimated cointegrating matrix.

Table C.3: Impact Impulse Responses – Estimated Cointegrating Relationship

	Sample Correlation between $\frac{CA}{Y}$ and y	$\frac{CA}{Y}$			y		
		π	τ^g	τ^c	π	τ^g	τ^c
ARG	−0.50	1.27	−0.55	−0.30	0.02	0.05	1.79
BRA	−0.08	0.47	−0.31	−0.58	0.71	0.04	0.61
CZE	−0.10	0.86	−0.27	−0.83	1.08	0.07	0.94
HUN	−0.27	−1.04	0.11	0.89	0.74	0.06	0.44
IDN	−0.08	−1.21	−0.30	1.36	1.52	0.30	1.94
KOR	−0.32	0.80	0.18	−1.52	0.84	0.99	1.04
MYS	−0.25	−0.58	−0.82	−2.79	1.40	0.48	0.24
MEX	−0.35	−0.25	−0.14	0.92	1.32	0.34	0.15
PER	−0.33	0.02	0.01	−1.22	1.42	1.78	0.21
PHL	−0.33	0.11	0.41	−2.17	1.75	0.55	0.20
POL	−0.50	0.50	0.02	−0.78	0.99	0.00	0.64
RUS	0.05	1.79	0.18	−0.61	1.08	0.34	1.49
ZAF	−0.39	0.33	0.05	−1.37	0.61	0.41	0.16
THA	−0.46	−1.11	−0.87	2.89	1.88	0.71	0.82
TUR	−0.55	−0.75	−0.25	−1.45	2.76	0.06	0.04
Median	−0.33	0.11	−0.14	−0.78	1.08	0.34	0.61
Mean	−0.30	0.08	−0.17	−0.50	1.21	0.41	0.71
Std Dev	0.18	0.90	0.37	1.47	0.64	0.47	0.62

Notes: The table shows the impact responses of the net exports to GDP ratio and income following the three structural shocks based on the estimated cointegrating matrix $\boldsymbol{\beta}$. Responses have been multiplied by 100 and corrected for the sign of the impact responses of output. The sample correlation between $\frac{CA}{Y}$ and y corresponds to the correlation between the net exports to GDP ratio and the cyclical component of the log of output, which has been derived using the HP filter with smoothing parameter 1,600.

Table C.4: Contemporaneous Forecast Error Variance Decomposition – Estimated Cointegrating Relationship

	$r^\star$		$\frac{CA}{Y}$			y		
	π	τ^g	π	τ^g	τ^c	π	τ^g	τ^c
ARG	18.13	81.87	80.36	15.03	4.61	0.01	0.09	99.90
BRA	27.54	72.46	33.50	14.34	52.16	56.85	0.15	43.00
CZE	6.67	93.33	49.51	4.66	45.82	56.40	0.25	43.34
HUN	4.72	95.28	57.24	0.65	42.11	73.36	0.44	26.20
IDN	13.98	86.02	42.93	2.72	54.34	37.51	1.43	61.06
KOR	49.94	50.06	21.58	1.12	77.30	25.53	35.15	39.32
MYS	21.47	78.53	3.81	7.68	88.51	87.27	10.19	2.54
MEX	31.10	68.90	6.70	2.13	91.17	92.57	6.28	1.15
PER	62.43	37.57	0.03	0.01	99.97	38.38	60.76	0.87
PHL	15.49	84.51	0.23	3.45	96.32	89.92	8.86	1.22
POL	0.01	99.99	28.50	0.04	71.46	70.80	0.00	29.20
RUS	0.01	99.99	88.85	0.93	10.21	33.21	3.27	63.52
ZAF	48.10	51.90	5.38	0.13	94.49	66.14	29.15	4.71
THA	35.68	64.32	11.87	7.33	80.80	74.83	10.87	14.30
TUR	1.51	98.49	20.83	2.38	76.79	99.94	0.04	0.02
Median	18.13	81.87	21.58	2.38	76.79	66.14	3.27	26.20
Mean	22.45	77.55	30.09	4.17	65.74	60.18	11.13	28.69
Std Dev	19.71	19.71	28.54	4.90	30.12	28.47	17.47	29.81

Notes: Percentage share of the contemporaneous forecast error variance explained by permanent, global transitory and country–specific transitory shocks, respectively, based on the estimated cointegrating matrix $\boldsymbol{\beta}$.

Moreover, Table C.4 presents the contemporaneous forecast error variance decomposition of our three variables. Again, we do not observe enormous changes in the outcome.

Hence, results reported in Tables C.3 and C.4 by and large corroborate the findings based on the theoretically imposed cointegrating matrix $\boldsymbol{\beta}$. Reassuringly, our conclusions from the main text do not alter substantially once we estimate $\boldsymbol{\beta}$.

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2005 – 2006	**Visiting and Exchange Student in Economics**, *University of Sussex*.
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Further Education and Invites

2013	**Financial Stability, jointly with Swiss Finance Institute**, *by Prof. Xavier Vives and Prof. Jean–Charles Rochet*, Study Center Gerzensee.
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Working Experience

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